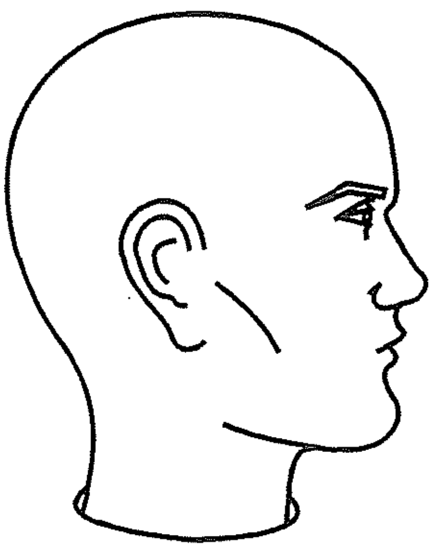
HUMAN ERROR CAUSED ACCIDENTS: ADDRESSING A CRITICAL PROBLEM

PROCEEDINGS

26th ANNUAL WORKSHOP ON HUMAN FACTORS IN TRANSPORTATION AND TRB SUMMARY SESSIONS 1 AND 40



Transportation Research Board of the
National Research Council
National Academy of Sciences
January 10-11, 1993, Washington, DC

PREFACE

These proceedings document activities from both the 26th Annual Workshop on Human Factors in Transportation and the sessions numbered 1 and 40 of the 1993 annual meetings of the Transportation Research Board. Both activities were coordinated by the Human Factors Workshop Planning Committee.

The proceedings are not meant to be a comprehensive and definitive collection of actual occurrences. They were developed from materials provided either by the presenters themselves, or from summaries abstracted from the presentations. While the materials are thought to represent the activities, they have not been verified in their final form by the principals involved. It is hoped that the information provided will prove useful in further efforts toward addressing human factors issues/problems in transportation.

It is a tribute to the many transportation professionals who have dedicated their expertise to addressing human factors issues, that this annual human factors workshop has been so successful over its 26 year history. As chairman of the Workshop Planning Committee it was my sincere pleasure to work with such a capable group of individuals and to find such constant and ready support from the modest, and exceptionally capable, Rick Pain at TRB. His guidance and the assistance of his staff, Katha Stewart and others, were instrumental in this year's success.

I would also like to express my appreciation to the session leaders and session participants. It is my hope that, with the expertise and dedicated cadre of those professionals active in the human factors and transportation areas, we can develop the human factors paradigms necessary for achieving higher levels of safety and efficiency in transportation.

Sincerely,

Alexander C. Landsburg
Chairman, 26th Workshop on
Human Factors in Transportation

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Richard F. Pain

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Group 3 - Operation, Safety, Maintenance of Transportation Facilities
- Committee on Traffic Safety in Maintenance and Construction Operations
- Committee on Vehicle User Characteristics
- Committee on Simulation and Measurement of Vehicle and Operator performance
- Committee on Pedestrians
- Committee on User Information Systems

Front: J.A. Wachtel, P.L. Drake, A.C. Landsburg, D.M. Freund, N.D. Lerner, C.W. Lynn, back: H.P. Van Cott, F.R. Hanscom, M.B. Mandler, J.K. Lauber, N. Seidle, G.H. Thomas, R.F. Pain.

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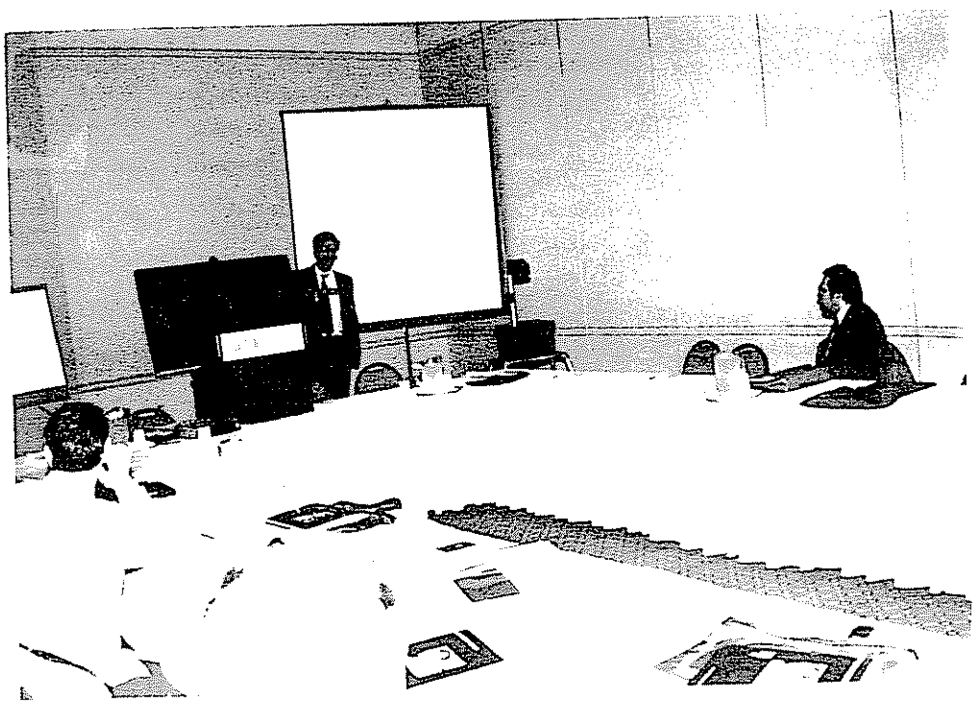


ACKNOWLEDGMENTS

These proceedings, and the activities reported, are the result of the combined and individual efforts by many. The Workshop Planing Committee worked hard in selecting topic areas that would be pertinent to the diverse interests of those involved in human factors and transportation. The Committee was also responsible for seeking out workshop presenters and contributors. Rick Pain and his assistant, Katha Stewart, are to be commended for their contributions to the planning, support, and success of the program. Praise is due to the workshop leaders and TRB Session presenters who skillfully developed valuable materials for presentation and discussion. The dedication of those individuals who took a Sunday out of their schedules to participate in the workshop sessions, in an effort to better understand today's human factors problems, is greatly appreciated. The constructive dialog of those who attended the Monday sessions is also appreciated. Finally, the assistance provided by Ram Nagendran, a graduate research fellow at the Maritime Administration, in gathering and consolidating the proceedings into a concise form, is acknowledged.

1. INTRODUCTION

Purpose and Background

The annual meetings of the Transportation Research Board (TRB) are held in January of each year. As has been the case for 25 years, a Workshop on Human Factors in Transportation was scheduled for the Sunday preceding the 1993 TRB meetings. It was decided, for the first time, to present the results of the workshop in focused sessions at the TRB meetings, both to share the results with the attendees at the TRB meetings and to give those who participated in one of the Sunday workshop sessions a chance to hear what was accomplished in the other sessions. It was further decided to capture the results of the workshop, and the related TRB sessions, in written proceedings. This document is the result of that effort.

Workshop Event

The 26th Annual Workshop on Human Factors in Transportation was held on Sunday, January 10, 1993, 9:00 am to 4:30 pm in the Sheraton Washington Hotel in Washington, DC. It consisted of eight individual, day-long sessions and featured a noon luncheon and keynote speaker. Each workshop session was intentionally limited in size to around 20 to 40 individuals. Workshop session formats varied according to the leader's preferences and usually included some prepared presentations with focused dialogue on particular issues.

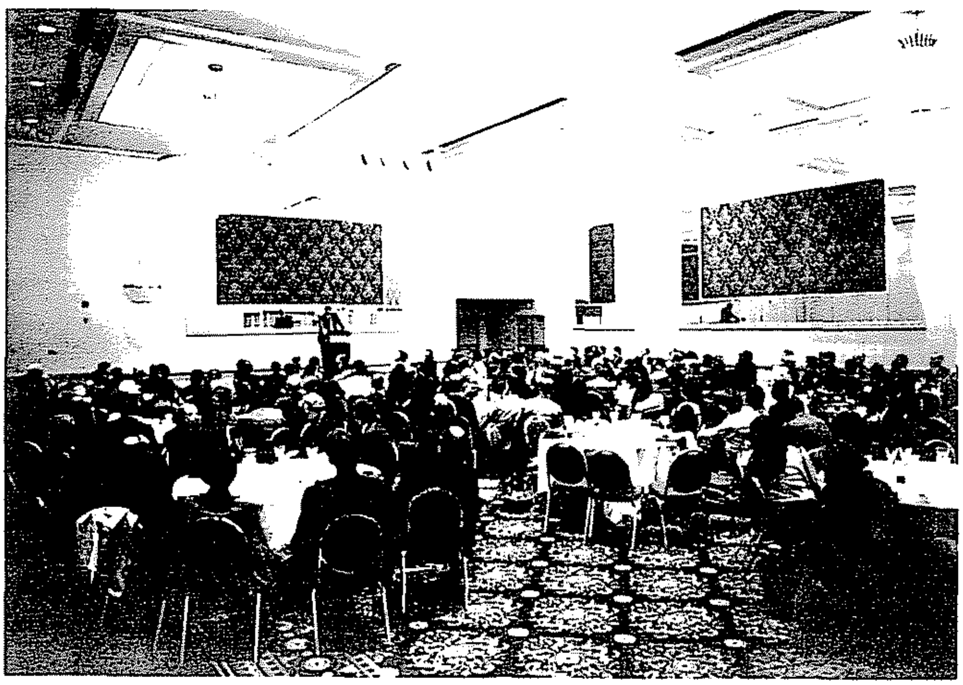
Monday TRB Sessions

TRB general sessions No. 1 "Human Error Caused Accidents: Addressing a Critical Problem" and No. 40 "Human Error Caused Accidents: Determining Operator Fitness for Duty" took place on the Monday morning and afternoon of January 11, 1993. These sessions consisted of several invited presentations and reports from the Sunday workshop.

Format of the Proceedings

The keynote presentation by the Honorable John K. Lauber at the Human Factors workshop is cited first in these Proceedings and delineates the scope of the problems that exist in the human factors area. The problem of human error and its relationship to accidents is reported as presented in Session No. 1 at the TRB meetings. Presentations at this session helped frame the concerns in transportation involved with human factors problems.

Reports from each of the workshops are found in Section 4. The reports were presented during TRB Session 1 or 40 but represent the work of the attendees over the full-day workshop on Sunday. In Section 5 the specific problem of fitness for duty is addressed with invited presentations from TRB Session No. 40. Finally a general summary and conclusions are offered. Appendices provide addresses of individuals involved in the sessions for the convenience of reader follow-up. An abstract data base search performed for the meeting by the Transportation Research Information Service (TRIS) is found in Appendix C.



Workshop Luncheon Address

2. WORKSHOP LUNCHEON PRESENTATION

2.1 A DECADE OF HUMAN PERFORMANCE INVESTIGATION

the Honorable John K. Lauber
Member of the National Transportation Safety Board (NTSB)
Washington, DC

Good afternoon. I am very pleased to be here today to talk with you about my favorite subject -- human factors in transportation.

As you know, the National Transportation Safety Board is an independent federal agency charged with investigating and determining the probable cause of transportation accidents and issuing safety recommendations to government regulatory agencies, industry or academia to improve transportation safety.

In 1983, the Human Performance Division of the Safety Board was created to assess the role of human error in transportation accidents. With the inception of this Division the Safety Board was, for the first time, able to systematically begin looking at specific behavioral and environmental factors that could be causal in transportation accidents and taking aggressive actions to prevent their recurrence.

With the development of the new division, a human performance protocol was designed to provide information on the operator's behavioral habits, medical background, and operational factors such as training, experience and company policies. Investigators also examined the task components involved, equipment design and environmental factors. Over time, this original protocol has been updated to include the systems perspective of cognitive and engineering psychology. These changes are particularly important in the field of aviation since modern computer technology and advanced avionics equipment influence human behavior patterns differently today.

Other changes have included a look beyond individual behavior toward examination of team performance and management behavior, and their influence on the corporate culture of work settings.

At the time the human performance program was developed, the Safety Board anticipated that some of the more typical and recurring issues that the Board had cited in previous accident reports, but which had proven to be elusive in terms of long-term accident prevention, could be more fully addressed with more in-depth analyses. The Safety Board has met with great success in addressing some of these issues while others have remained elusive. I will spend the next few minutes describing some of each.

Drug and Alcohol Impairment

The continuation of programs begun in the 1970's to reduce drug and alcohol use and limit their effects on the safety of the traveling public has been an ongoing priority with the Safety Board, which has issued more than 130 recommendations covering testing, education, rehabilitation, enforcement and legislative efforts.

One early effort was aimed at deaths on the nation's highways caused by young drinking drivers. Through recommendations made in 1982, the Safety Board initiated a successful effort to raise the legal drinking age to 21 in all states.

The Safety Board has also focused on the problem of repeat offenders, which account for up to 30% of drunk driving convictions. In 1984 the Safety Board issued a study of general deterrence techniques and recommended that States implement prompt administrative revocation of drivers' licenses as an integral part of TWO enforcement and penalty programs. Since the recommendations were issued, 31 states have adopted this important countermeasure.

Other areas of concentration include the Safety Board's effort to get states to address the problem of alcohol use in recreational boating and in general aviation. Research indicates that better than 30% of fatally injured boat operators have a BAC of more than 0.10 at the time of the accident and more than 60% of all fatalities in boating accidents have some level of alcohol in their system.

While commercial aviation is virtually the only mode of transportation not spoiled by the effects of alcohol, a recent study by the Safety Board reveals that the role of alcohol in general aviation warrants closer attention and appropriate recommendations have been made.

Preventing alcohol involvement in transportation accidents remains an object of intense effort for the Safety Board. Yet, given even this level of effort, we continue to investigate accidents in which alcohol impairment is clearly indicated. Recently, the Safety Board completed an investigation of a New York City subway derailment in which five passengers were killed. The Safety Board determined that the blood alcohol content of the motorman at the time of the accident was between 0.29 percent and 0.36 percent.

The March 1989 grounding of the EXXON VALDEZ in Alaska also clearly demonstrated the role alcohol plays in transportation accidents.

At 9:00 p.m. on March 24, 1989, the U.S. tanker, under the control of the third mate who had only limited experience, ran aground on Bligh Reef in Prince William Sound. The grounding ruptured several of the tanks, causing one of the largest oil spills in history. Nearly $2 billion has since been spent on the clean up. Exxon reported the lost oil was worth approximately $3 million, and the tanker's damage was estimated to be $25 million.

In its deliberation on the accident investigation, the Safety Board determined that the probable cause of the accident was, in part, due to the ship master's alcohol-impaired decision to leave the relatively inexperienced and fatigued third mate in sole control of the ship at a critical time. It is estimated that the BAC of the master at the time of the grounding was above 0.20.

In addition to a previous hospitalization for alcohol dependency, the master also had two previous drunk driving convictions -- one only six months prior to the accident at which time his BAC was 0.19.

Fatigue

The Safety Board has investigated many accidents in which work schedules, sleep loss, fatigue and/or circadian factors are clearly implicated. One of the most perplexing problems our accident investigators face is how to determine what, if any, role fatigue played in a specific accident. Unlike metal fatigue, human fatigue leaves no telltale signs, and we can only infer its presence from circumstantial evidence. We are constantly seeking to develop better investigative techniques, which in turn should lead to better ideas for preventive measures.

Virtually always, an attempt is made to reconstruct the on-duty/off-duty/rest/sleep/wake history of the key operational personnel involved in an accident. Frequently we find horror stories that leave little doubt as to cause. But much more frequently, what we find is ambiguous, inconclusive, and

I'm sure in some cases, downright misleading. As a result, the true incidence of fatigue as a causal or contributory factor is largely unknown.

The professional sleep research community is currently working -- both independently and with federal regulators -- on providing us with more concise methods and theoretical formulations for determining the contribution of sleep factors to accident causation. This work will undoubtedly lead to the development of more informed public policy guiding the design and operation of our transportation system.

An example illustrating the problems and difficulties I've described follows.

On February 19, 1985, China Airlines flight 006, a Boeing 747 enroute to Los Angeles, California from Taipei, Taiwan, suffered an inflight upset. The airplane was flying at about 41,000 feet mean sea level when the No. 4 engine lost power. During the attempt to recover and restore normal power on the engine, the airplane rolled to the right, nosed over, and entered an uncontrollable descent. The captain was unable to restore the airplane to stable flight until it had descended to 9,500 feet pulling more than 5 g's in the process. The plane was then diverted to San Francisco where a safe landing was made. Although the airplane suffered major structural damage, only two persons among the 274 passengers and crew on board were injured seriously.

The Safety Board determined that the probable cause of this accident was the captain's preoccupation with an inflight malfunction and his failure to properly monitor the airplane's flight instruments, which resulted in his losing control of the airplane. Contributing to the accident was the captain's overreliance on the autopilot after the loss of thrust on the No. 4 engine.

Although the Safety Board was unable to determine conclusively that the captain's performance was impaired by fatigue, the investigation revealed that he had experienced alterations in his regular sleep cycle, was subject to prolonged work periods, and had experienced a poor quality of sleep during the week preceding the flight. For these reasons, there was a high probability that he was affected by circadian desynchronosis at the time of the accident.

Other accidents are more straightforward.

On November 7, 1990, at 4:11 a.m. in Corona, California, westbound AT&SF train 818 passed a stop signal on a siding, re-entered the main track, and collided head-on with eastbound AT&SF train 891. Each train had three-person crews; the entire crew of train 818 and the brakeman on train 891 were killed in the accident. Total damage as a result of the accident was estimated to be $4.4 million.

The investigation revealed that the engineer of train 818 had a work schedule that was irregular and unpredictable. During the 64-day period prior to the accident, he worked 47 days, during which he was called to duty 56 times, and had 35 different reporting times. On 25 occasions he reported to work 8 hours or more later than he had on the previous day, meaning that he changed shifts 46 percent of the time.

He had little more than 6 hours of sleep over the 48-hour period leading up to the accident and he had complained to his wife prior to the accident trip that he was "exhausted."

The investigation revealed that the conductor and brakeman of train 818 were also subject to irregular and unpredictable work schedules and quite likely suffered sleep deprivation similar to that of the engineer.

The Safety Board determined that the probable cause of the collision was the failure of the engineer of train 818 to stop his train at the stop signal because he was asleep. Contributing to the accident was the failure of the conductor and brakeman to take action to stop the train, probably because they too were asleep. Also contributing to the accident were the irregular and unpredictable work schedule of the engineer on train 818, the AT&SF Railway Company's lack of policy or procedure for removing crew members from service when they are not fit for duty because of lack of sleep, and the inadequacy of Federal rules and regulations that govern hours-of-service.

Based on these and many other accident investigations, we have repeatedly advocated the need for an aggressive Federal program to address the problems of fatigue and sleep issues in transportation.

Training and Experience

One fact has become clear - the well-trained, well-supported, well-motivated professional is the greatest safeguard we have in minimizing human error accidents. This is a fundamental human performance issue.

The Safety Board has issued more than 650 training related recommendations covering every mode of transportation. I believe that the severity of the training deficit is evident just by virtue of the numbers of recommendations issued.

Recently, the Safety Board completed an investigation of a Greyhound bus accident that clearly reflects this critical need for effective training. On June 26, 1991, a Greyhound bus traveling from Cleveland, Ohio to Washington, D.C. ran off the roadway and overturned on the Pennsylvania Turnpike near Donegal, Pennsylvania. One passenger died and the driver and 14 passengers were injured. The bus driver had recently been hired and had "successfully" completed Greyhound's 144.5 hour training program. The accident trip was her second unaccompanied trip for Greyhound.

Passengers on board the accident bus reported that, during the first portion of her trip, she repeatedly demonstrated her inability to safely control the bus or negotiate the route. She missed turns, hit fixed objects, drove off the road, ran other vehicles off the road and made many other illegal and unsafe maneuvers.

The Safety Board determined that the cause of the accident was, in part, "Greyhound's failure to ensure that the bus driver had adequate training and experience to operate an intercity bus."

While this accident shows why we cannot underestimate the importance of good training, it also clearly demonstrates that no amount of training can entirely compensate for inexperience.

It is necessary to recognize that for a period immediately following training, whether it is for a new position or a new piece of equipment, a process psychologists call consolidation takes place during which the new knowledge and skills learned are put into more permanent memory. During this period of time, individual performance is slower and more deliberate, and more prone to "blunder" type errors. For this reason, we have issued numerous recommendations regarding the use of newly trained but inexperienced operators.

To address this problem in aviation we have recommended that special operating and scheduling restrictions be put in place to prevent the pairing of neophytes in routine flight operations.

An accident involving Continental Airlines during a snowstorm in Denver, Colorado in 1987 illustrates the point. The airplane was cleared to take off following a delay of approximately 27 minutes after de-icing. The takeoff roll was uneventful, but following a rapid rotation, the airplane crashed off the right side of the runway. Both pilots, one flight attendant and 25 passengers sustained fatal injuries. Two flight attendants and 52 passengers survived.

Although the captain was an experienced pilot with good flying skills, he was relatively inexperienced as captain on air carrier turbojet airplanes, and he had very little flying time in the DC-9. He was not seasoned in either the supervision or judgment of first officers, nor was he familiar with the unique characteristics of the DC-9-10 series airplane in icing conditions. The first officer had flown one line trip accumulating approximately seven hours of flight time following his training, and then was put on reserve and was given no flight time for the next 27 days. The accident flight was the first officer's second line flight following completion of his training a month earlier. This had the effect of literally wiping out much of the skill and knowledge acquired during his training program -- psychologists have long known about rapid forgetting immediately following training unless the skills are exercised. He had 36 hours of jet experience.

In its investigation, the Safety Board found the absence of regulatory or management controls governing operations by newly qualified flight crew members to be contributory to the accident.

Less than two years later, the USAir flight 5050 runway overrun at La Guardia Airport confronted us with another inexperienced crew pairing issue. This issue has since been addressed not only for pilots, drivers and other operators, but for Air Traffic Controllers, maintenance personnel, dispatchers and others outside the vehicle whose actions affect the safety of operations.

Conclusion

The topics I've discussed here today are just a few of the many issues the Safety Board has looked at over the years. They are representative of the kinds of typical recurring problems we continue to encounter. And, while we have made many in-roads to understanding some problems and recommending solutions, others remain elusive.

As I mentioned earlier, as the human performance protocol for investigating accidents evolved, it became apparent that accidents and incidents involving individual performance in isolation are infrequent events. Much more common are accidents involving human error in which institutional and organizational factors play a critical role. As such, the Safety Board's message has changed over the decade.

We frequently find the system accountable for the human error in accidents because we believe that every accident, regardless of its seeming simplicity, is the result of multiple causes and factors. Similarly, every human error, regardless of how grievous, is a product of multiple causes and factors. While the actions of individual pilots, engineers, drivers, ship's captains or others do occasionally cause accidents, responsibility for these accidents rest within a larger context -- the performance of individuals never takes place in a vacuum, but always occurs within an organizational and cultural context.

BIBLIOGRAPHY

JOHN K. LAUBER
Member
National Transportation Safety Board
Washington, D.C.

John K. Lauber became a Member of the National Transportation Safety Board in November 1985.

Dr. Lauber is a research psychologist who began his career at the U.S. Naval Training Devices Center in 1969. He came to the Safety Board from the National Aeronautics and Space Administration where he directed the Aeronautical Human Factors Research Office at NASA's Ames Research Center. He has worked extensively with airlines, cockpit crews and affiliated organizations throughout the world on safety issues that involve human factors.

Dr. Lauber was president of the Association of Aviation Psychologists and chairman of the Aerospace Medical Association's Aviation Safety Committee. He served as assistant technical director of a Presidential task force on airliner crew size, and as a member of the Institute of Medicine panel at the National Academy of Sciences that reviewed scientific evidence relating to the mandatory retirement of airline pilots at age 60.

Dr. Lauber was elected Fellow of the Aerospace Medical Association in 1983, is a member of the Human Factors Society and has served on numerous national and international committees and commissions. He has received numerous awards and honors, including: NASA's outstanding leadership award (1985); the Flight Safety Foundation/Aviation Week and Space Technology's distinguished service award (1987); the Aerospace Medical Association's Raymond F. Longacre Award (1990); Air Transport World's Industry/Public Service Award (1990); and the National Air Traffic Controllers Association Joseph T. Nall Memorial Award (1992). He has been the Board Member on scene at several major accident investigations.

A general aviation pilot, Dr. Lauber holds a commercial license with both fixed-wing and helicopter ratings. He is also type-rated in the B727 jet aircraft.

Dr. Lauber is a native of Archbold, Ohio, and holds three degrees from Ohio State University. He received a doctor of philosophy degree there in 1969. Dr. Lauber is married to the former Susan Elizabeth Myers. Their daughter, Sarah Nelson, is a teacher in the Mesa, Arizona, public school system.

Dr. Lauber's current term on the National Transportation Safety Board expires December 31, 1994.

3. HUMAN ERROR CAUSED ACCIDENTS: ADDRESSING A CRITICAL PROBLEM

Mr. Alexander C. Landsburg, Presiding Officer, Office of Technology Assessment, Maritime Administration, Washington, DC

The importance of reducing human error was the focus and guiding purpose and philosophy behind the activities of the 26th Human Factors Workshop and TRB Sessions 1 and 40. The general thesis stated:

transportation accidents involving human error are a critical problem needing attention.

Accidents tend to have multiple causes. Generally, prevention of any one of the causes either prohibits the accident from occurring or reduces the effects of the accident. Historically statistics have shown that approximately **60 to 80 percent of all accidents have involved human factors either as the primary or contributing cause.**

This percentage has not changed significantly over the years despite regulatory actions and technological improvements. Recent accidents in marine, rail, and other modes of transportation have captured public attention as the National Transportation Safety Board has released findings of operator fatigue and other human factors issues.

The solution to reducing human error may involve,

development of a sharper focus on total systems design and operation with special and continuing attention given to the human element as a critical and integral part of the system.

The human element must be carefully integrated along with every other part of the system to ensure safe and reliable operability. Continued failure to properly address the human element during design and operations is considered a serious problem needing immediate attention.

The material presented in this section of the Proceedings was presented in TRB Session 1 on Monday, January 11, 1993. The presentations begin with Dr. Pain's description of the long history of the Human Factors Workshop and follow from Dr. Lauber's keynote address featuring accident statistics, case histories, lessons learned, and theories on why accidents occur.

Several reports from the Sunday Workshop sessions were featured during Session 1 and are provided in section 4 of this document.

Dr. Rick Pain (left) at workshop.

3.1 INTRODUCTION

Dr. Richard F. Pain, Safety Coordinator, Transportation Research Board, National Research Council, Washington, DC

For 25 years there was always a Human Factors in Transportation Workshop on the Sunday before the TRB Annual Meeting. This, the 26th year of the Workshop is different. The Workshop took place on Sunday but this conference session, held during the Annual Meeting, is the first real attempt to make the outcomes of the Workshop sessions immediately available to a wider audience. Implementation and technology transfer is a continuing concern in transportation research and certainly is and continues to be one in human factors and ergonomics. Through the summaries presented at today's session and later publication of these summaries the thought, expertise and experience of over 150 people who spent a day together can be captured and made available to a much wider audience.

Until 1976, when the Highway Research Board became the Transportation Research Board, the Human Factors Workshop focused exclusively on highway, driver and vehicle related topics. The Workshop Planning Committee in 1976 immediately broadened the scope of the workshop to include all modes of transportation. In the years since, sessions on rail, aviation and transit are found in the programs. Now the full spirit of the multimodal scope of the Workshop is evident. Topics of interest and relevance to all modes, especially maritime, are on the program.

TRB is very pleased to welcome the many individuals representing rail, maritime, aviation and transit modes who attended the workshop sessions Sunday and are in the audience of this session. I hope you found the Workshop sessions and similarly find today's conference sessions interesting and useful.

I want to acknowledge the leadership of the Workshop Planning Committee Chairman, Mr. Alexander Landsburg of the Maritime Administration, U.S. Department of Transportation. Through his ideas and persistence workshop topics of interest across all modes were included in the Workshop. He organized this session as an experiment to see if results of the Workshops could be widely disseminated. This Circular is the result of his work following the Workshop. Many participants and Planning Committee members over the years have wanted a way to document the Workshop. Mr. Landsburg is the first to make that objective a reality.

In conclusion welcome to a unique session of the TRB Annual Meeting. Judging from the packed room the idea struck a responsive chord. Please let TRB know your opinion of this experiment. Thank you for your attendance and interest and I hope you enjoy the session.

3.2 ASSESSMENT OF HUMAN ERROR FROM TRANSPORTATION ACCIDENT STATISTICS

Dr. Vernon Ellingstad and David L. Mayer, Office of Research and Engineering, National Transportation Safety Board, Washington, DC

Introduction

Baker and Lamb (1992) have recently reported on a study of commuter and air taxi accidents during the period from 1983 through 1988. They obtained data from the National Transportation Safety Board's Aviation Accident Data Base on a total of 719 fixed wing aircraft involved in 122 commuter and 597 air taxi accidents and subjected these data to an extensive process of analysis. They identified twelve major crash categories (as well as an "other" and an "undetermined" classification) that provided useful groupings of the Part 135 accidents for more focused analysis. They also evaluated each accident record to determine whether factors associated with (a) the pilot, (b) ground personnel, (c) air traffic control, (d) aircraft malfunction, (e) airport conditions, and (f) weather had contributed to the accidents. Pilot condition or pilot error was identified in about 74 percent of these accidents. Human factors issues such as fatigue, improper procedures, and decision errors were observed for individual cases and emerged as safety issues when the cases were aggregated. The Baker and Lamb study provides a useful description of an important class of aircraft accidents.

At last year's Transportation Research Board meeting Hegwood (1992) presented an analysis of general aviation accidents from 1988. She attempted to evaluate the prevalence of human factors issues in these accidents by applying a modification of Feggetter's (1982) checklist to a sample of 50 general aviation accident records in the NTSB data base. She coded cognitive, social and situational human factors in these accidents after inspecting the NTSB factual reports, briefs of accident and accident narratives. Her analysis identified human factors as contributing to 90 percent of the 50 accident sample, as compared to 82 percent that had been originally identified by the NTSB as caused or contributed to by human factors. Flaws in information processing (80 percent of the accident sample) and errors in judgment or decision making (66 percent of the sample) were particularly notable findings. Again, this study provides useful descriptive information to the aviation safety and human factors communities by examining aviation accidents in the aggregate.

On October 14, 1992 the Safety Board adopted a study of alcohol and other drug involvement in fatal general aviation accidents during the period from 1983 through 1988. This study revealed a small decline in the number and percent of alcohol related general aviation accidents over the study years, to a rate of about 6 percent in the late 1980s. A slightly higher proportion of alcohol related fatal (to the pilot) crashes occur at night than is the case for fatal (to the pilot) crashes that do not involve alcohol. Disappointingly, no strong evidence of differential causation between alcohol involved and non-alcohol involved accidents emerged from the study -- that is to say we did not discover human failures that were clearly associated with alcohol impairment in these accident records. This study depended, of course, on factual and analytic data derived from the NTSB Aviation Accident Data Base.

As a final example of what I am sure that you have guessed by now to be illustrations of the application of accident data bases (and their associated accident statistics) I would like to mention a study that is currently in progress in the Safety Studies Division at the Safety Board. This study is an assessment of flight crew performance in Part 121 air carrier accidents determined by the Board to have involved flight crew error. Ben Berman and his colleagues are now in the process of refining taxonomies of flight crew errors that were identified through a detailed analysis of accident data, including factual and analytic records, as well as cockpit voice recorder transcripts and other investigative information. They are also deriving, from the same data sources, empirical characterizations of operational factors such as workload, situational awareness and communication flow whose relationships to flight crew error can then be assessed. We hope that this analysis, in the aggregate, of a fairly large collection of major air carrier accidents will reveal some of the human performance issues that may not be readily apparent in a single accident.

The balance of this paper will explore a couple of issues that affect the usefulness of accident databases for safety research generally, and human factors research in particular. Mayer and Ellingstad (1992) note a number of problems in the use of accident data bases designed for purposes other than research and analysis, including: treatment of missing data; database structure and design; and representativeness of the records in the database. These are important technical considerations that will influence the quality and usefulness of accident research, but they are outside the scope of our discussion today. Instead, I would like to concentrate on two issues: (a) the importance of examining accidents in the aggregate, and (b) the need for improving our measurements of "cause" .

Why Bother With Accident Statistics?

The National Transportation Safety Board (NTSB) is a premier accident investigation agency and it produces definitive analyses of individual transportation accidents. These analyses are based on extensive field and laboratory investigations, a party system that ensures the consideration of widely differing points of view, and very extensive deliberation. They produce, in most cases, a normal statement of the "probable cause" of the accident, and, where appropriate, recommendations for action to correct safety defects. You will shortly have evidence from my colleagues Jim Danaher and Jerry Walhout of the impressive scope and quality of these investigations. Why then do we bother to collect and analyze collections of accident data stored in our computers?

The first answer to this question has to do with seeing the forest, in addition to all of the individual trees that are represented by the separate accidents. Assessment of accident trends requires the aggregation of data from all of the individual accidents that are investigated. Standardization of data elements and methods of data collection have obvious importance in accounting for the patterns of accidents over time, as do considerations of reliability and validity of the data that these trends are based on.

A second, and perhaps even more important rationale for aggregate analyses (accident studies) is that accident causes are not always evident, even to the most extensive, well organized, and professionally conducted single investigation. Sometimes this is due to the presence of what we might call "weak causes", influences which, in a statistical sense, account for only a modest (but reliable) proportion of the variance. Other accidents, or classes of accidents, may be produced by multiple causes that interact in complex ways. It should not be surprising that the kinds of causes that we are focusing on today -- the human factors -- are often (if not usually) both weak and multiple.

Finally, transportation accidents always occur in a context that must be understood and accounted for. The influence on accidents of factors such as operator workload, hours of service, task complexity, and the like can probably only be understood statistically -- that is, on the basis of aggregate studies of accidents for which the requisite human performance data has been collected.

Measuring Accident Causes

The Safety Board makes an important formal distinction between "fact" and "analysis" in its investigation of accidents. The investigative process often yields a body of "fact that describes and documents the accident circumstances and that supports "analysis" intended to yield an assessment of probable cause. Similarly, in addition to a collection of factual information, the accident database may include analysis and some representation of the cause(s) of accidents.

One of the implicit assumptions of accident analysis has always been that if the *cause* of an accident is known, similar accidents can be prevented in the future. This notion has its roots in fault tree analysis. If specific accident-producing modes of failure can be identified, then accidents can be prevented by strengthening those weak links. Some failure modes (e.g., metal fatigue or tire failure) are relatively well understood and more importantly, they leave identifiable physical traces that survive the accident. Human failures, however, generally leave little direct evidence for later analysis. Consequently, accident databases usually capture more information representing hardware failures and other directly observable phenomena, than human errors .

Grouping similar accidents by type or category is perhaps the simplest and most common representation of causation in accident data bases. While it is often possible to classify accidents as belonging to a specific type (e.g., mid-air collision, VFR into IMC, loss of control, etc.), this rarely explains why an accident occurred. Accidents -- even relatively simple ones -- often result from multiple causes.

Some accident data bases address this issue by recording a narrative statement of accident causation, generally produced by a trained analyst, using a somewhat structured vocabulary. The Aviation Safety Reporting System (ASRS) maintained by NASA (Rosenthal and Mellone, 1989) utilizes this kind of text-based key-word system. The NTSB Aviation Accident System also contains a 200 word narrative statement of probable cause, although this is not the primary method of recording accident causes in the NTSB database. While this approach provides the opportunity for rich expression of causal relations, methods of analysis for text data are, at present, limited.

The current NTSB aviation database uses a somewhat more complex coding system that identifies from one to five *"occurrences"* that make up the accident *Sequence of Events.* Associated with each occurrence is a "Phase of Flight" code.

For each occurrence/phase of flight listed the accident investigator also records a set of coded explanations or "findings" that account for that occurrence. A primary set of findings consisting of a "subject" (23107 - Altimeter), a "modifier" (3121 - Misread), and a "person" (4000 - pilot in command) can be entered to account for the occurrence. An underlying explanatory factor (e.g., 33130 - physical impairment, alcohol; pilot in command) can also be associated with this occurrence. The sequence of events system is intended to comprehensively represent the events in a single accident in a formal coding structure that permits the examination of common patterns across accidents of particular types.

This approach is complicated somewhat by the fact that more than one "sequence of events" may be necessary to account for a particular accident. In many accidents a simple chronological listing of occurrences in the order in which they occur is sufficient to account for accident causation. In other circumstances the causal sequence of events may be different from the temporal sequence of events. This is particularly true when factors that significantly pre-date the accident sequence of occurrences (e.g., maintenance failures, pilot sleep loss, etc.) must be causally associated with accident events.

An additional complication in attempting to capture the details of accident causation in a sequence of events coding structure concerns the assessment of relationships between multiple accident factors or findings. It would be useful, for example, to assess the extent to which the pilot's sleep loss contributed to his vigilance decrement, and how much that in turn contributed to failure to detect a critical signal. Current database redesign efforts at the Safety Board are directed to the incorporation of such information in the sequence of events data system.

A related issue in quantifying accident causation is the assessment of the strength of the relationship of each separate occurrence or factor in the sequence of events to the accident itself. Military aviation investigation systems have, for example, indicated which event in the sequence made the accident inevitable. The Safety Board does not presently code that information.

While possessing great potential explanatory and analytic power, coded representations of causal chains such as that just described can be very complicated to use. Current efforts to improve the Safety Board's database are directed to improvements in this area as well.

Additional Information needed to account for human causes

In addition to documentation of the factual aspects of an accident and an assessment of causation; a human factors analysis is an important component of a full investigation. In this context "human factors information" must be understood to refer to a complete accounting of human-equipment interaction in the accident situation, and not the "mental state" or disposition of the people involved in the accident. There must, for example, be a thorough accounting of task demands placed on the operator as well as the operational requirements of the task(s). Preferably, this analysis should be standardized across all accidents in the database. In effect, what is needed is a retrospective task analysis which helps to identify and code system failures. Drury (1983) detailed several such alternatives for coding consumer product accidents, but no such method has emerged for transportation accidents. The need for standardization and the realization that not all accident investigations will be conducted by professionals trained in human factors, suggests that checklists or other "cookbook" methods may be needed.

Conclusions

Transportation accident databases will continue to provide the primary basis for most empirical diagnoses of safety problems and evaluations of safety countermeasures. Improvements in database technology as well as database design can be expected to make these sources of information increasingly useful but significant attention must be directed to improving both the collection and analysis of relevant data regarding the circumstances, contexts and causes of accidents -- and particularly the human factors.

Task-oriented human factors information about accident scenarios is often missing or unusable in transportation accident databases. This kind of information is sometimes overlooked because of an inadequate understanding of human factors by accident investigators. More often, however, these data are not collected because human failings do not leave the same kind of permanent physical traces that broken vehicular component do.

Sometimes human factors information, and other analytic findings, are collected but not coded well or completely. Improved methods of quantifying causality, and representing relationships between multiple causes are needed to render databases more useable in this regard.

Human factors researchers should and need to use accident databases in their work, but great care must be taken to use these tools effectively. Greater participation by researchers in the design of databases and the collection of data will increase their suitability for our work.

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3.3 DIVERSITY OF HUMAN ERROR: AN AVIATION CASE HISTORY

Mr. James Danaher, Office of Aviation Safety, National Transportation Safety Board

Good morning, ladies and gentlemen I am pleased to be here and to participate in this very worthwhile session on Human Error - Caused Accidents. Our previous speaker has provided a general overview of human error involvement in transportation accidents across the various transportation modes. As a followup to that presentation I would like to share with you an aviation accident case history which illustrates the diversity of human errors and their underlying causes. I hope to illustrate by this accident example the importance of identifying the underlying causes of such human errors, if we are to be successful in reducing their frequency.

On the night of February 1, 1991, shortly after dark at Los Angeles International Airport, a USAir B-737 landed on runway 24 left and immediately collided with a Skywest commuter aircraft that was sitting on the same runway, awaiting clearance for takeoff. All 10 passengers and 2 crew members aboard the commuter and 20 passengers and 2 crew members aboard the B-737 were fatally injured.

The accident occurred as a direct result of the actions of several controllers and pilots. However, there were numerous contributing or enabling factors underlying these actions that are perhaps far more important from an accident prevention standpoint, than the precipitating, actions themselves. Let's address the proximate events first, then address the underlying factors later.

In the Los Angeles tower about two minutes before the collision, the concentration of the local controller was momentarily disrupted and, as a result, she forgot that she had cleared a Wingswest commuter aircraft onto the runway, ready for takeoff. Further, when she misidentified another nearby aircraft on the airport as being the one in question, she cleared the arriving USAir flight to land on the same runway. The crew of the arriving aircraft failed to see the commuter aircraft sitting on the runway on which they were about to land, until the collision was imminent and unavoidable; and the crew of the commuter aircraft failed to hear the controller's radio transmission clearing USAir to land on the runway which they occupied. Several questions immediately arise in this case:

o How could the local controller **forget** that she had cleared the commuter aircraft onto the runway?

o Having done so, why didn't she discover and remedy her mistake?

o How could the USAir flightcrew **not** see the commuter aircraft sitting on the runway ***on which they were about to land ?***

o How could the commuter aircraft sit for two minutes on runway 24 left, and not question the local controller or overhear USAir's clearance to land there?

The Safety Board's investigation of this accident found answers to these questions, and these answers warrant brief discussion for our purposes today.

The ATC communications on the tower frequency during this time indicated that more than 60 transmissions occurred from the time the arriving USAir flight came on the frequency until the accident. Although this high level of activity probably reduced the likelihood that the Skywest commuter crew would hear the landing clearance, it normally should not have prevented it.

In addition to the previously mentioned controller performance errors, there also were deficiencies in supervisory controller performance at the Los Angeles tower which were relevant in this accident. Six weeks prior to the accident, the local controller's supervisor conducted an "over-the-shoulder" evaluation and identified deficiencies that indicated weakness in her performance. Two of these performance deficiencies -- loss of awareness of aircraft separation and aircraft misidentification -- were again evident in the local controller's performance on the night of the accident. Post-accident investigation disclosed that, although the supervisor had completed the evaluation and discussed these items with the controller, he did not initiate other remedial action.

The Safety Board's official statement of the probable cause of this accident cited " the failure of the Los Angeles Air Traffic Facility Management to implement procedures that provided redundancy comparable to the requirements contained in the National Operational Position Standards and the failure of the FAA Air Traffic Service to provide adequate policy direction and oversight to its air traffic facility managers. These failures created an environment in the Los Angeles Air Traffic Control tower that ultimately led to the failure of the local controller 2 (LC2) to maintain an awareness of the traffic situation, culminating in the inappropriate clearances and subsequent collision of the USAir and Skywest aircraft. Contributing to the cause of the accident was the failure of the FAA to provide effective quality assurance of the ATC System."

A review of this probable cause statement and other related findings in the Safety Board's report of this accident,makes it clear that the Board identified numerous human errors by individual controllers and pilots that led to the collision; but, perhaps more importantly from an accident prevention standpoint, it also found numerous deficiencies in FAA management performance, including first level supervision up through policy level management. The Safety Board issued 17 safety recommendations to the FAA as a result of its investigation of this accident and, to its credit, the FAA has initiated positive corrective action in response to most of them.

In summary I have used a case history approach to illustrate the diversity of human errors involved in a recent, major air carrier accident. And I have shown that the causes of these human errors fall under broad categories that include: supervision and management, the work itself, the physical environment, equipment design, and worker/co-worker interaction. Undoubtedly, human error cannot be reduced to zero; however, if we hope to eliminate serious accidents, we must design systems that are error tolerant and that include adequate safety margins. Finally, to be effective in applying preventive human error countermeasures, we must identify and address the many underlying factors that contribute to these errors. I'll be glad to respond to any questions you may have, --- if time permits. Thank you!

3.4 RECENT SURFACE TRANSPORTATION ACCIDENTS AND LESSONS LEARNED

Gerrit J. Walhout, Office of Surface Transportation Safety
National Transportation Safety Board

I am pleased to be able to address this TRB session on Accidents Caused by Human Error. I hope that I can contribute in a small way to this worthwhile and interesting meeting.

The topic this morning is on the lessons learned in recent surface accidents. As you know most accidents are not caused by mechanical failures or environmental conditions. Depending on the mode of transportation, human factors are the cause in 70 to 85% of all accidents.

In recent years, the Safety Board routinely attempts to uncover the specific reasons why the operator behaved or failed to behave appropriately. The human performance investigator digs deeply into individual life style issues, reconstructs duty/rest cycles and attempts to establish the medical histories of the operator, including his or her abuse of drugs and alcohol. In short, the investigator attempts to find the underlying reasons for the specific behavior that caused the human error to occur.

These investigations have found that the sources of human error are as diverse as they are pervasive. They include error of judgment; faulty decision making; breakdowns in communications; and failures in coordination and supervision, among a host of other factors. Often we can do little to correct or alleviate such behavioral oriented factors. But one causal factor keeps cropping up in our accident investigations that can be addressed and that one is called training, skills or experience.

As you know, human error can be categorized along a continuum of operator behavior and actions (Wickens 1984). On one end are skill-based behaviors, which stress perceptual motor functions. In the middle are rule-based, cognitive behaviors. And decision making and knowledge-based behaviors are on the other end of the continuum. To counter these human errors, training is provided in most transportation modes. However, the adequacy of this training often comes into question after an accident.

To illustrate some of these issues, I would like to share with you several recent accident cases in which training became the overriding concern. One such accident concerned the derailment of a Amtrak passenger train, operating from Washington, D.C. to Boston, Massachusetts. The train operated uneventfully from Washington to New Haven, Connecticut. A relief crew,comprised of a locomotive engineer, an apprentice engineer, a conductor and two assistant conductors, came on board in New Haven. The apprentice engineer was enrolled in Amtrak's locomotive engineer training program and authorized to operate trains while under supervision.

The trains maximum authorized speed was 100 mph. An event recorder registered the train's speed, throttle position and brake pressures among other parameters.

The apprentice engineer was at the controls as the train approached Back Bay Station in Boston at 109 mph. The engineer instructed the operator to begin braking in anticipation of a 30 mph speed restriction at the tunnel entrance to the station and the negotiation of a 9 degrees 30 minutes right hand curve inside the tunnel. The event recorder data showed that a single full-service brake application was made about 4 to 5 thousand feet before the point of derailment and that the throttle position was changed from full throttle to idle between 3100 and 4000 feet from the point of derailment. The last recorded speed was 76 mph when the locomotive overturned in the curve.

According to manufacturer braking graphs, the stopping distance of this train would have been slightly more than 9000 feet if full service braking had been applied and the train would have required a distance of about 5000 feet to reduce its speed to about 30 mph if emergency braking had been applied. The instructor engineer had been a locomotive engineer for 21 years and had operated locomotives on this territory for most of his career. Early in his career he had served as a class room instructor and as a road foreman for another railroad. In that capacity one of his functions was to qualify locomotive engineers for passenger service. Since 1983 he had served exclusively as a locomotive engineer for Amtrak and served as a instructor engineer on numerous occasions.

The apprentice engineer had entered Amtrak's training program about 6 months prior to the accident. He had operated a train into Back Bay Station two times prior to this trip but this was the first time that the apprentice received instruction from this engineer.

The signal system approaching Back Bay Station was not intended to restrict the movement of trains unless special conditions, such as other trains, interfered with unrestricted movement. Amtrak relied completely and singularly on the engineer's ability to know his precise location at all times and to relate special instructions such as the speed restrictions to that location. The Safety Board's analysis found that Amtrak, while allowing training to take place at this location, did not recognize the potential for human failure when it established the procedure for the slowing conditions required to enter Back Bay station. Amtrak should have realized that no redundancy was provided to assure that the slowing condition at that location would be complied with.

The Safety Board also found that Amtrak's training programs did not provide for the development or evaluation of its instructor engineers. It neither prepared engineers for teaching, supervising and evaluating apprentices nor did it seem cognizant of the high workload that the training task can impose on an instructor engineer.

This accident illustrates that the role of management is no less critical in the achievement of safety than the action and attitudes of the operator. The lesson we learn here is that no training programs or human error avoidance program can be fully successful if management does not acknowledge its role and set the tone in the development of operational safety standards.

Another example of how management's failure to recognize its role in the setting of safety standards can result in accidents are two highway accidents which were investigated by the Safety Board within about one month of each other on June 26 and August 3, 1991. The accident involved 2 Greyhound buses, one operating from Cleveland, Ohio to Washington, D.C. and the other from New York City to Buffalo, N.Y. Both buses ran off the right side of the roadway and overturned. Both accidents involved the monitoring and evaluation of the training and licensing processes of newly recruited drivers and the adequacy and follow-up of behind-the-wheel training and the cubbing process of new drivers. (Cubbing refers to an OJT program designed to familiarize the drivers with operational and route information after initial training).

The first accident bus was operated by a 23 year-old driver who had finished a 3 week training program for intercity bus drivers about 20 days prior to the accident. The driver's training history reflected that she obtained a regular drivers licence in 1987 but had not owned a car until 1990 and had driven perhaps 30 miles per week since that time.

She had obtained an Ohio chauffeur learners permit with a passenger commercial drivers licence (CDL) endorsement a week prior to the start of her training. The driver began a 3-week training program on May 19, 1991 and graduated on June 6, 1991. Her training record reflected poor driving skill performance and the evaluation forms for her first week of training did not reflect a score higher than "poor" for any driving skill evaluated. The driver graduated second from last in a class of 67 students.

This driver needed to obtain a CDL before she could be issued a commercial driver licence in Ohio. She failed the General Knowledge test once; the Passenger Transport test once; the Airbrake Test twice; and the Road Test once.

The driver began her 10 day "cubbing" training immediately after graduating. Her cubbing records could not be found but Greyhound stated that the driver's training included trips from Cleveland to New York City, Cleveland to Syracuse, Cleveland to Columbus and Cleveland to Cincinnati. Additionally, she was taken to Cleveland area locations for additional training. However, the accident driver stated to the Board that she only went to New York City once and otherwise was limited to driving in the Cleveland area. On these trips she was variously rated from "needs more practice" to "satisfactory".

On the day of the accident, the driver was called at 1:00 am and told to report for duty at 3:00 am. She performed various tasks at the terminal and was able to get some rest for 1 1/2 hours before she was called again at 6:00 am. At the time of the accident she had been on duty for 11 hours and had been behind the wheel for 5 1/2 hours. The bus had departed Cleveland at 8:30 am for Washington DC with 4 intermediate stops enroute. This was the drivers' second unsupervised trip. Between Cleveland and Pittsburgh the driver became lost several times and had trouble locating entrance ramps to major highways. Passengers complained about excessive and sudden braking, drifting into other lanes, speeding and dangerous lane changes. Two passengers made a formal complaint to Greyhound in Pittsburgh but were rebuffed and later reported the incidents to the Highway Patrol.

It is evident that, despite the 3 weeks of formal driving training and after passing the necessary CDL tests, this driver was unprepared to safely drive a commercial bus. It is also evident that Greyhound had sufficient warning that this driver was unprepared to independently operate a bus.

The implications of this accident might have gone unnoticed if not a similar accident had occurred about one month later in which a Greyhound bus ran off the road on a scheduled run from New York City to Buffalo N.Y. on August 3, 1991. Investigation into the background of the driver revealed circumstances remarkably similar to those of the driver of the previously investigated accident.

The driver was 26 year old. He had been a resident of New York City for most of his life. He had moved to Washington, D.C. in 1990 where he obtained a learner's permit and later obtained a chauffeur's license. He had never owned a car and his driving experience was limited to an 8-month period when he occasionally had driven a passenger van and a 24-foot U-haul truck.

The driver began his bus driver training on April 25, 1991 and graduated on May 17, 1991. He graduated 3rd from last in a class of 52 students. His first week of training reflected poor grades but after 3 weeks received excellent scores. The driver's cubbing consisted of taking turns driving with other students on a empty bus to New York City, Atlantic City, Cleveland, Roanoke, Winston Salem and Philadelphia. Greyhound could not supply records of this training. The driver had received 3 1/2 hours of sleep prior to reporting for duty and had been driving about 5 1/2 hours when the accident occurred. The driver was unfamiliar with the route and was following another bus closely in order to avoid getting lost. Passengers complained about speeding and following too closely. The Safety Board concluded in its report on these two accidents that neither driver possessed adequate driver skills to operate a bus safely.

The lessons we can draw from these accidents are these: while the driver may be the "last line of defense" in the prevention of accidents, many individuals and organizations share responsibility for safety in any transportation system. Consider the following, for instance:

The drivers may not have been as alert as we would have liked to see them; however, a great deal of responsibility for a driver's alertness rests with those who produce schedules and make responsible assignments of drivers.

The drivers may have lacked the necessary skills to operate passenger buses; but, a great deal of responsibility rests with those who recruit and screen drivers applications for minimum qualifications and with those paid to oversee. evaluate and document driver performance. In evaluating the safety in a transportation system it is possible to show a chain of responsibility that reaches all the way to major Federal agencies. For instance, in this case the Office of Motor Carrier Safety (OMCS) conducted periodic compliance and safety reviews of the motor carrier but appeared to concentrate on the appropriateness of the paper work only.

The Federal Highway Administration sets minimum national standards for licensing commercial motor vehicle drivers. It also developed a model curriculum for training of truck drivers in 1984. However, FHWA does not regulate training schools or training standards. The States administer CDL programs and issue CDL's which have been required now since January 1992. These programs often are contracted out and administrative oversight, let alone quality control, is difficult at best.

I do not want to leave you with the impression that our surface transportation modes are unsafe. The Safety Board has seen some significant improvements over the years in both operating safety as well as equipment design. But more importantly, we have seen an increasingly knowledgeable outlook on safety issues by transportation organizations. These are promising signs. However, we must continue to look forward for opportunities to make the system safer. The travelling public demands as much.

3.5 A THEORY OF ACCIDENTS: MISPERCEPTION OF RISK

Dr. Herschel W. Leibowitz, Pennsylvania State University, University Park, PA and Dr. D. Alfred Owens, Franklin & Marshall College, Lancaster, PA

The role of risk-taking in accidents is of great concern to human factors research for both practical and theoretical reasons. Transportation safety depends heavily on a vehicle operator's ability to perceive and evaluate risks accurately and then to adjust his or her behavior appropriately. In some cases such as drinking while intoxicated and driving, or neglecting to use seat belts, the risks are well known or clearly evident, yet an individual may act inappropriately because of misjudgment of the personal danger associated with the risky behavior. In other situations such as landing airplanes or driving at night, the risks are imperceptible or obscure, and inappropriate behavior occurs because of failure to perceive the actual hazards of the operating environment. In both types of situations, an operator's failure to adjust behavior in order to compensate for changing or unperceived levels of risk can lead to a serious accident.

This view suggests that underestimation of risk can have multiple origins. Theoretical discussions of risk-taking behavior may benefit from elucidation of the role of basic perceptual limitations as opposed to cognitive misjudgments. A clearer understanding of the cause of dangerous risk-taking should contribute to the development of more effective methods to modify, eliminate, or compensate for the inappropriate behavior. Thus, improved theories of risk-taking and their fruitful application may follow from a clearer delineation of the perceptual and cognitive origins of risky misbehavior. We explore this possibility through examination of two examples of risky behavior that pose serious threats to traffic safety.

Alcohol

Alcohol is clearly insidious to traffic safety. Accident statistics indicate that it is a contributing factor to as many as 50 percent of traffic fatalities. It seems reasonable to assume that most drinking drivers are aware of the hazards of drinking and driving although their behavior would suggest otherwise. The problem has been mitigated by recent media campaigns against drinking and driving, but it has not yet been solved. How can a theory of risk-taking be applied here?

Drinking and driving appears to be an obvious example of risk-taking that follows from bad judgement. The dangers are well publicized, yet the offender chooses to ignore or to discount the personal risks involved. This sort of misjudgment might be attributed in part to the mood-altering characteristics of alcohol intoxication, particularly feelings of well-being, aggression, and exaggerated self-confidence. It might also be related to a more subtle aspect of alcohol, namely the *inability of drinkers to appreciate their level of intoxication.* Behavioral and psychophysical studies show that the effects of alcohol on performance are highly variable and that impairment is only loosely correlated with blood alcohol levels. In addition, there is experimental evidence that subjects are not able to evaluate their level of intoxication. The data indicate that (1) alcohol increases self-confidence, (2) has variable effects on perceptual-motor performance, and (3) self-judgements of intoxication are unreliable and often invalid. In light of this research, it is not surprising that a drinking driver is inclined to take inappropriate risks. The abilities to judge and to perceive the immediate risks of drinking and driving are masked by the physiological and psychological effects of the drug itself.

With respect to road safety, regulatory efforts in the United States appear to have concentrated on identifying a blood alcohol level that corresponds to the threshold of impairment. Many states consider blood alcohol levels below 0.10mg/% to be legally acceptable while others have designated 0.08mg/%. Is this an appropriate standard or useful strategy for addressing the problem? We suggest that this approach is unrealistic in light of the research literature. Given that alcohol impairment varies widely and often affects performance well below the current legal thresholds of intoxication, and that individuals are generally unable to judge accurately their own level of intoxication, it seems arbitrary and unwise to certify any blood-alcohol level as legally acceptable for driving .

From this viewpoint, the prevailing legal standards are difficult to justify and are tantamount to misinformation. While the serious hazards associated with drinking and driving are widely recognized, there is an implicit message that moderate drinking is compatible with safe driving, and it is left to the operator to determine the immediate risks. Unfortunately, a drinking driver is particularly ill-equipped to judge the risks of his/her current behavior. Rather than condoning moderate levels of drinking, it seems more appropriate to move, as some European nations have, toward discouraging all drinking and driving. More generally, the lesson drawn from the human factors perspective is to avoid promulgation of regulations that hold operators responsible for making judgements that are likely to exceed their capability.

Night Driving

The majority of road fatalities occur at night. Accident statistics show that, when corrected for mileage, the nighttime fatality rate runs three to four times higher than the daytime rate. Although multiple variables undoubtedly contribute to this problem, reduced visibility appears to be a key factor. Extensive evidence shows that most drivers (even the sober alert ones) habitually "overdrive their headlights" at night.

Despite severe limitations of acuity, visibility, and contrast sensitivity, traffic speeds are typically as high in low illumination as they are in daylight. Allowing for normal perception and response time, the stopping distance from 55 mph is approximately three times the distance at which one can recognize a dim unexpected obstacle, such as a pedestrian, illuminated by low-beam headlights. If Motorists were to adjust their speed to assure their ability to avoid collision with such hazards, they would not drive more than 18-20 mph at night when using low-beams. Obviously, it is a rare driver who avoids the serious hazards imposed by visibility limitations at night.

Basic research on vision suggests that this type of risk-taking behavior is related to fundamental properties of vision. Recent research in neurophysiology and psychophysics has established a distinction between recognition and guidance vision. Recognition vision, the more familiar mode, is concerned with tasks such as reading or identifying persons or objects. Guidance vision subserves spatial orientation such as walking or steering. Under daylight illumination levels, both of these modes function maximally. However, with lower illumination, as in twilight or night driving, there is a selective degradation of the recognition mode of vision. Recognition vision is precipitously reduced while visual guidance is relatively unaffected. As long as there is some (even very dim) illumination available, drivers are able to steer their vehicle accurately. Because they are able to effectively maintain alignment with the roadway, drivers are unaware that their ability to recognize hazards, which depends on the degraded recognition mode of vision, has seriously deteriorated. As a result, drivers maintain an inappropriate level of confidence, and are unprepared for encounters with unexpected low contrast hazards.

Considered from the standpoint of risk-taking, one might assume that the nighttime traffic accidents are the outcome and therefore the fault of motorists who are taking inappropriate risks. But, this interpretation seems unrealistic from the present perspective because an operator cannot be held liable for neglecting risks that are unknown and imperceptible. This is another instance where the regulations are not appropriate to the operators' ability to assess the hazard of the situation. The operator cannot perceive the actual risks of nighttime driving, and speed limits serve more to obscure than to inform the operator of those risks. It may be impractical to legislate new speed limits that are low enough to preclude "overdriving" low-beam headlights. Alternatively, the traffic safety community must exert greater efforts to educate the general public about the problem and to eliminate or minimize the occurrence of unseen hazards, e.g., improved markings of heavy trucks, pedestrians, and cyclists.

In this case, the lesson drawn from the human factors perspective is that a major component of the risky behavior found in nighttime driving can be attributed to the natural limitations of human perception rather than to recklessness or poor judgement.

General Considerations

Underestimation of risk can have multiple of origins and can be found in a variety of transportation accident scenarios. For example, the several visual/optical illusions at rail-highway grade crossings result in an overestimation of the time to collision and may be responsible for many vehicle-train accidents. Misestimation of altitude has been suggested as a contributing factor to nighttime landing accidents in aviation. Indeed, many accidents, not limited to transportation systems, can be attributed to lack of awareness, misevaluation, or failure to perceive risk.

Understanding the basis for particular classes of risk-taking behavior will provide the most promising foundation for development of more effective ameliorative measures. A logical and promising approach is to inform operators of potential hazards about which they are-not normally aware. Educational campaigns are potentially effective and relatively inexpensive. Operation Lifesaver, a public media campaign to communicate the dangers associated with grade crossings, has reduced the frequency of these accidents. Campaigns against drinking and driving have had a dramatic effect. Adoption of differential day/night speed limits would create an awareness of the special hazards of nighttime driving.

It is indispensable that regulations for transportation and licensing take into account the capabilities and limitations of the human operator. In view of the current state of our understanding regarding the effects of alcohol on performance, many of the present regulations are both unrealistic and dangerous. Given the poor visibility of pedestrians in the nighttime environment, it is quixotic that current regulations require drivers to be able to stop their vehicle in time to avoid striking an object which they cannot see in time to take appropriate evasive action. Pedestrians should be made aware of the visibility limitations of drivers and advised to <u>never</u> assume they can be seen by an approaching motorist. If it is necessary to be on the highway, they should be required to wear appropriate visibility-enhancing clothing. Existing laws for both highways and railroads should be modified so that the responsibility for nighttime pedestrian accidents is shared by both the vehicle operator and pedestrians rather than, as is now the case, focused on the operator.

Safety engineering and regulations must be grounded in a basic understanding of human performance. Although there are many unsolved and challenging problems for which solutions are wanted and wanting, there currently exists a wealth of information in the behavioral sciences literature which is relevant to traffic safety but which has not been implemented. The milleu provided by this meeting is a fertile medium for the exchange of information to take advantage of unexploited data and to highlight directions for future research. It is our view that the unprecedented costs in human suffering now associated with our transportation system can be reduced not only by engineering innovations but also by a more insightful consideration of human factors principles.

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4. REPORTS FROM WORKSHOP SESSIONS

Reports from each of the workshop sessions that took place on Sunday January 10, 1993, are provided in the following section. The same participants in each session met together all day in deliberations except for a luncheon at which Dr. Lauber presented his keynote address.

Each workshop session was organized by the session leaders with planning assistance by the members of the Workshop Planning committee. In several sessions, resource people provided focused presentations or materials to assist with the work. In all cases the object was to utilize the differing background and expertise present to develop the problem and address the issues to the greatest extent possible in the limited time. Brief reports of the workshop session activities were presented to the TRB attendees in both Sessions 1 and 40 on January 11, 1993. All of the reports are provided in this section of the Proceedings.

4.1 HOURS OF SERVICE - RETHINKING AN EARLY 20th CENTURY CONCEPT FOR THE 21st CENTURY

Martin Moore-Ede, Institute for Circadian Physiology, Harvard Medical School and Circadian Technologies, Inc. and
Martin M. Stein, Circadian Technologies, Inc. and Center for Transportation Studies, M.I.T.

Introduction

All modes of transportation--road, rail sea and air--are highly susceptible to accidents caused by human fatigue and loss of alertness. In the early part of this century hours of service (or rest time/duty time) legislation and regulations were enacted and promulgated to address such problems. These placed maximum limits on the number of consecutive hours on duty and minimum limits on the number of hours of rest, irrespective of the time of day. Regulations in several modes of transportation still have no limit on the number of hours worked in a given time period nor do any existing regulations deal with fatigue caused by irregularity in rest and duty hours.

Two factors make it important to re-appraise the hours of service concept as we approach the21st century. First, we have become a twenty-four-hour society with increasing demands for transportation around-the-clock at higher speeds over longer distances with tighter time schedules. Second, considerable advances have been made over the past twenty years in the understanding of human circadian rhythms, alertness and sleep physiology and the causation of human-fatigue related accidents. For example, there is increasing evidence to show that time of day (or more accurately circadian phase) may have as much influence on accident probability as does hours on duty per se.

This workshop reviewed the circadian and sleep/alertness physiology underlying human-fatigue related accidents, provided updates on the status of operator fatigue research programs being conducted in various transportation modes in the USA, Canada and Australia and discussed the feasibility of various possible alternatives to, or improvements of, hours of service regulations.

In a wide ranging and lively discussion of the issues involved, a number of conclusions were reached about the effectiveness of current hours of service recommendations and barriers to change. Also a number of recommendations were drafted which workshop participants thought merited further study. These conclusions and recommendations are outlined below:

Conclusions

1. The current hours of service regulations do not have a basis derived from empirical scientific research. They are intuitive attempts to regulate fatigue risks and are based on limited data, if any at all.

2. The hours of service regulations in their current state do not address or prevent many of the well documented causes of fatigue and loss of alertness in transportation operations.

3. The regulations vary between transportation modes (road, rail, air, marine) with little objective justification. There are, however, strong similarities in the risks between modes and large variations within modes, particularly in crew/operator factors and day/night chronicity.

4. Currently, there are no research based alternatives to existing hours of service regulations.

5. There are significant obstacles to change. These include:

*The high capital costs of the infrastructure investments made by companies based on the existing hours of service regulations (e.g., LTL trucking terminals placed I0 driving hours apart).

*The absence of an overall strategic plan to address the development of hours of service alternatives.

*The resistance to experimentation from organizations with a vested interest in maintaining the status-quo for fear of a reduction in allowable hours of service.

*The correlation between employee earnings and existing regulations.

*The extremely high cost of collecting data in "real world" environments.

Recommendations

I. Regulations directed at preventing accidents caused by fatigue (or more accurately, reduced alertness) must incorporate the considerable scientific advances in circadian rhythms, alertness, sleep and related human factors research.

2. An overall strategic research, development, testing, and evaluation (RDT&E) plan should be developed to give direction to attempts to improve and eventually replace the existing hours of service regulations. Without a coordinated effort

resources will be wasted, and cost-effective interventions could be delayed unnecessarily or missed entirely.

3. Opportunities should be created for trials of creative alternatives and improvements. It is not reasonable to wait ten or more years for a "complete understanding" to emerge on how to prevent fatigue. Much can be gained by limited operational trials of innovative ideas.

4. Incentives need to be devised to encourage corporations, unions and individuals to change undesirable practices which cause excessive fatigue. For example, it is currently much cheaper (in the short term) to work a small staff for excessive hours of overtime than it is to hire extra employees. Similarly, dangerously fatiguing work hours may reward an individual with a doubled or trebled salary.

5. Fitness for duty systems in a broader context offer promise as an important enhancement to rational hours of service regulations. These systems should be continuous or semi-continuous, unobtrusive, reliable and noninvasive

6. Research should be pursued on I) analysis of automatic behavior states, 2) factors that influence alertness (e.g. caffeine), 3) evolving technology of alertness measurement (e.g. alpha attenuation tests), 4) design of alternative strategies (e.g., incentives) and 5) intersection effects of biological, economic, and sociological factors.

4.2 FROM MONOTONY TO CRISIS: EFFECT OF WORKLOAD TRANSITION ON TRANSPORTATION OPERATORS

Dr. Beverly M. Huey, Committee on Human Factors, National Research Council, Washington, DC, and Dr. Christopher D. Wickens, Aviation Research Laboratory Willard Airport, University of Illinois, Savoy, IL

Workload transition describes situations in which a team of operators function for some period of time under relatively routine conditions and are suddenly confronted with abnormal and/or emergency circumstances. The team must respond rapidly in order to maintain normal operations or prevent a disaster. In such circumstances, coordination and communication are crucial in mitigating the potential consequence(s) of substantial risk to the health and safety of the team, the environment, and others.

This workshop session examined individual and team performance issues affected by transitions in workload and discussed means to reduce the possible negative consequences of these transitions in a number of transportation modes including aviation, rail, marine, and emergency medical services systems.

A number of factors that affect the performance of a crew during workload transitions were highlighted: crew communications, sleep loss and circadian rhythms, stress, training, and workload. Other environmental, operational, and individual variables also affect performance, but it is not known what combined effects they may have.

Basic comparisons were made among the transportation systems of interest--the operating conditions, environment, nature of various crisis situations, and possible responses to emergencies. In order to be able to compare and contrast these systems, data must be obtained, but an examination of data sources (psychological experiments, accident reports, and incident reports) revealed many problems. Psychological experiments were assessed to be oftentimes too abstract, while accident reports are often too infrequent and determined causes too ambiguous to generalize. Data from incident reports could be useful but many incidents go unreported and, therefore, these data bases are incomplete and may not accurately represent the majority of incidents.

Many of the transportation systems have data bases that contain information on accidents and incidents, from which some of the data used for comparison can be obtained. Examples of the data bases discussed that are currently in use include the following: (1) ASRS--the Aviation Safety Reporting System, (2) MINMOD--the Marine Investigation Module, and (3) the National Transportation Safety Board's data bases, such as that on emergency medical services helicopter accidents. It was concluded that researchers are a long way from having good models and that there is a lack of data from research as well as a lack of systematic data from the real world. It was stressed that the application of conclusions from one domain to another must proceed cautiously, but that much insight and advances could be achieved by a sharing of knowledge in this area.

Brief overviews of the effects of workload transitions on cognitive *switching, decision making, communications, task management, geographical* orientation, and vigilance were given. Much of the discussion that followed, then focussed on decision making.

Shortcomings in decision making may result from limitations in a number of processes necessary to execute a decision, from initial gathering of information to final choice. A necessary, but not sufficient, precondition for good decision making is the existence of a correct hypothesis of the most likely state of the world within which the chosen action will be carried out. Certain biases and heuristics may create distortions in hypothesis formation and situation awareness; these were also discussed. The efficacy of human decision making varies as a function of many factors, including statistical estimation requirements, memory, extent of operator practice, and type of behavior involved (e.g., skill based, problem solving). At each level in the system, given the mission goals and current situation, the decision maker(s) must select an appropriate strategy, adopt tactics that support the selected strategy, and effectively communicate with others. Several pitfalls in information processing to which individuals can fall prey occur in the following: (1) top-down perception; (2) working memory; (3) prospective memory; (4) confirmation bias; (5) over confidence; and (6) risk assessment. An example of error in top-down perception is hearing what one expects to hear and not what is actually said. In working memory, one is more *likely to transpose digits and to make spatial errors when in a crisis situation* thus implying a greater need for visual supports. Prospective memory errors, such as forgetting to do something, suggest a need to have automation reminders and to keep humans in the communication loop. Confirmation bias describes the decision maker's tendency to look for new information to support his current hypothesis and to ignore or undervalue information that runs counter to his hypothesis.

Over confidence and risk assessment refer to a decision maker's tendency to overestimate the probability of a positive rare event occurring (e.g., winning the lottery), and to underestimate the probability of a negative rare event occurring (e.g., having an aircraft emergency landing). When individuals must choose between two negative outcomes, they usually are biased to choose the risky option. When their choice is between two positive outcomes, the bias is to select the sure thing. However, when a group has to make a decision, the outcome is often different than the decision the individuals alone would have made. To illustrate this, a "risky shift" demonstration was used in the workshop.

A "choice dilemma" was given and workshop participants were asked to select the minimum odds they were willing to assume and still advise taking the risk. After they wrote down their odds, three-person groups were formed, and each group was asked to arrive at consensus on the risk it was willing to take. The average risk of the groups was greater than the average risk individuals were willing to take. The lesson demonstrated that groups operating on a plurality or majority principle, which most do when instructions emphasize the group nature of the task, naturally produce a majority decision--which is likely to favor risk, since the item produces individual responses skewed in that direction and hence the "risky shift."

A number of remediation measures to counter some of the problems that occur in decision making during crises were discussed. They include: the use of decision aids, debias training, domain training, and the development of team cohesion. The group agreed that the use of decision aids and the development of cohesion appeared to offer the most benefit at this time.

A number of effective team qualities were also identified by workshop participants, including effective leadership, commitment, unit cohesion, motivation , understanding of one's responsibilities in the team, clear procedures, positive relations between groups, and open communication. Videos, demonstrating both effective and non-effective teams, were shown: (1) "Why Airplanes Crash, which reviewed the crash of Eastern Airlines L1011 in the Everglades in 1972 when the flight crew, preoccupied with a landing gear problem, failed to monitor the aircraft's altitude, and (2) one on Cockpit Resource Management, which reviewed the performance of the crew of United Airlines flight 232 who safely landed a severely crippled airliner that had lost its steering control near Sioux City.

Finally, the workshop identified means that can be used to reduce negative consequences as well as the remediation of potential performance degradations--crew resource management training, system design, task design, organizational climate, automation, and other types of training.

4.3 AN INTERMODAL REVIEW OF HUMAN-MACHINE INTERFACE AND STANDARDIZATION

Dr. Thomas L. Saunders, Transportation Systems Development Division, Sandia National Labs, Albuquerque, NM, and CDR Charles Klingler, U.S. Coast Guard, Washington, DC

A group of people well versed in their field of human interfaces with control centers met to share their knowledge. Transportation modes discussed were automobile, trucks, aircraft, and railroads. The discussion was led by Dr. Tom Sanders. To insure our discussions remained on target, we focused only on the human factors in the control centers of only these modes of transportation. We first wanted to determine the current state.

Mr. Dave Benedict from Toyota presented the automobile interests and gave a snapshot of human factors considerations. One specific activity he learned not to do was to mount the mirror control device down and away from the operator.

Mr. Steve Huntley of the Volpe National Transportation Systems Center told of aircraft cockpit arrangements. He spoke of the evolution of indicators from dials to square video screens with multiple displays.

Ms. Deborah Shust of Navistar told of the "belly limits" for truck drivers. We were intrigued by her discussion of how the human was built around the truck and few changes had been made in the last two to three decades.

Mr. Ken Watkins from AMTRAK explained about the new locomotives being built to travel at speeds of over 120 miles per hour. He also told how the operator's station was being updated from multiple indicators, each incrementally installed over the years, to one video screen.

After much churning of ideas and spirited discussion, the group supported the statement that STANDARDIZATION IS DESIRED in each mode for the following four reasons (in priority order):

1. For emergency responses; to obtain a desired response in a short time.

2. To change human behavior; We have forced the driver to use the turn stalk for the horn versus the steering button (air bag).

3. To save money in manufacturing costs.

4. To avoid accidents; Putting 'nice' things (such as radio buttons, window cranks) in a standard location allows their operation while still focusing on driving.

Of course, no one could agree on what to standardize or how to go about it. There was consensus that, where possible, we must standardize intuitively. The best way is to use empirical evidence. If that is not available, consider expert advise. The human being responds best to small, incremental changes.

At the conclusion, we all agreed that we had begun to pioneer networking to begin discussing standardization not only in the same modes, but more dynamically, across the modes.

Examples of across-mode standards would be consistent labeling, symbology, and color coding. A simple first step would be to make turn signal controls the same for cars and trucks.

Our final discussion centered on the best process to begin across-mode standardization. Two alternatives seemed to conflict: Voluntary action and regulated requirements. The former seemed more doable but much harder to enforce 'maverick' standards. The latter appeared much more expensive and slower to implement. Clearly, a voluntary effort would be more effective by "partnering" with each other in a focused effort to introduce standardization and increase safety.


TRB

4.4 ATTENTIONAL IMPAIRMENT IN DRIVING

Mr. Thomas H. Rockwell, R & R Research, Inc., Columbus, OH, and Dr. Ronald R. Knipling, Office of Crash Avoidance Research, National Highway Traffic Safety Administration, Department of Transportation, Washington, DC

Focus

The focus of the workshop was in four major areas:

1. establishing the role of inattention in traffic crashes

2. defining the concept of attention and distinguishing between various sources of attentional impairment, e.g., the unalert driver

3. measurement issues in attentional impairment and its precursors

4. methods of warning and control of attention through design of vehicles and driver aids. In the latter case, the workshop explored the potential offered from IVHS technology.

Key Questions

Key questions directed to the attendees at the beginning of the workshop are shown below.

1. What constitutes a useful operational definition of driver inattention? driver alertness?

2. What is the relationship, if any, of driver alertness to inattention?

3. What percentage of accidents (near accidents) ascribed to inattention are caused by low levels of driver alertness?

4. Is driver alertness a researchable topic in the lab? in a simulator? on the road?

5. Is "driver alertness" subject to measurement operationally for research purposes? for practical use?

6. Would self tests of alertness be possible? be useful?

7. Is driver inattention a researchable topic in the lab? in a simulator? on the road?

8. Are there measurable precursors to driver inattention?

9. Is inattention related to Heisenbergs Principle of Uncertainly, (once you probe for it, its gone)?

10. Does IVHS offer any promise in terms of realerting drivers or directing their attention to driving tasks? Does the false alarm problem negate the value of any countermeasure?

Problem Significance

The importance of the inattention problem to highway crashes was demonstrated by both the Indiana TriLevel Study and sample data from NASS. It has long been recognized by accident investigators that inattention plays a major role in traffic crashes. A detailed assessment of 74 rear-end crashes from the 1991 National Accident Sampling System (NASS) revealed that driver inattention was the primary causal factor in 85 percent of the crashes. Ongoing assessments of other crash types have indicated a major role for driver inattention. The Indiana TriLevel, in-depth, on-site crash investigation found recognition errors to be the most probable factor in 56 percent of reported driver errors. The recognition errors included inattention, internal and external distraction, and improper lookout. Clearly, attentional lapses are a significant factor in crash occurrence.

In current clinical assessments of various crash types it was noted that inattention was implicated in 85 percent of rear end crashes and 88 percent in backing crashes. In 70 to 80 percent of lane change/merge crashes, the driver did not see the other vehicle. In 27 percent of single vehicle roadway departures. the driver was inattentive or fell asleep. Drowsiness was cited in 72,000 police reported crashes in 1989.

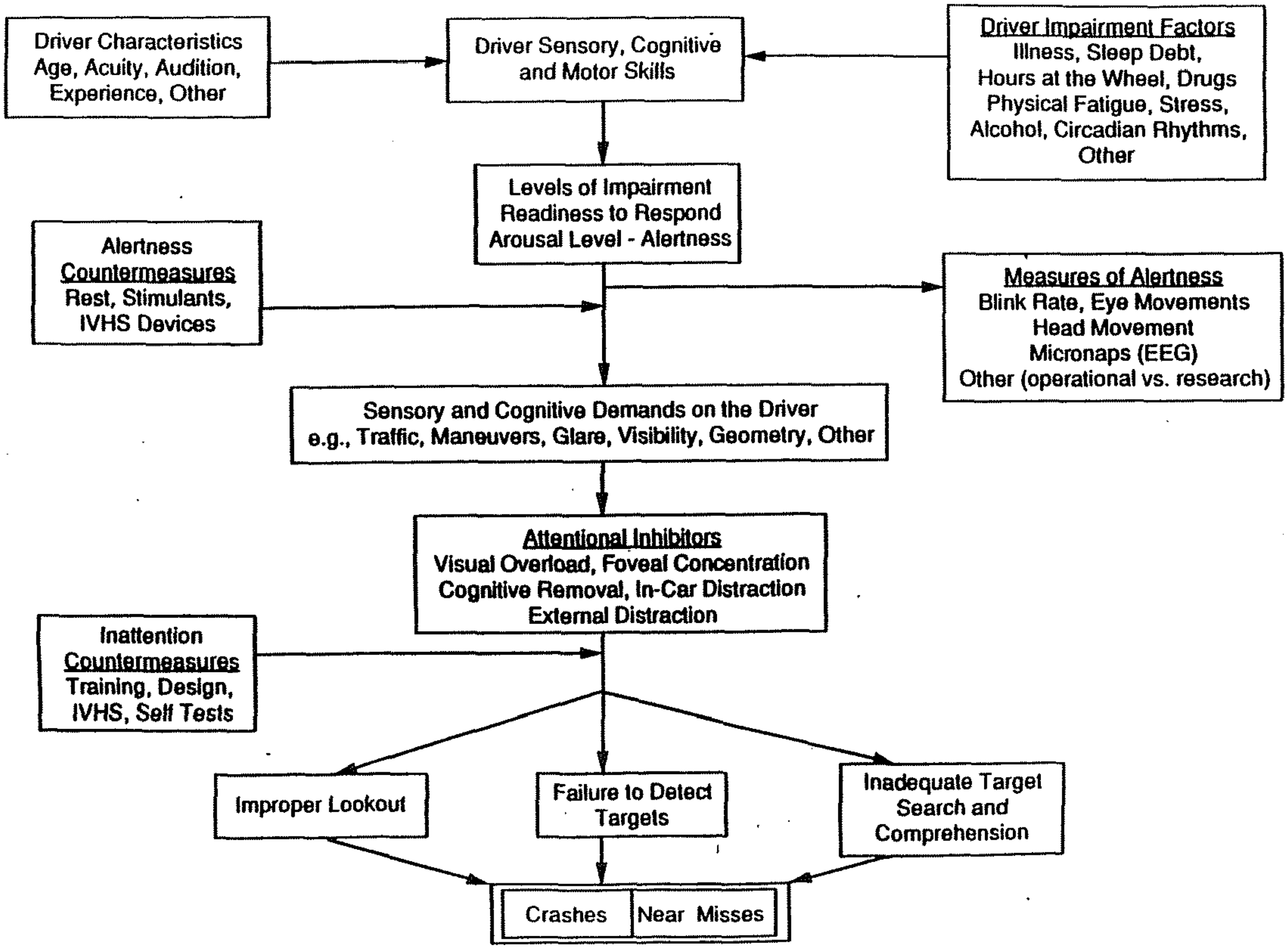
Scope of the Issue

The complexity of the issue is shown in Figure 1. Workshop attendees agreed that inattention or inappropriate divided attention in driving is distinguished from the drowsy or unalert driver which has known causal structures.

Definitions of alertness are better delineated than inattention which is operationally related to lapses of performance.

Just how much "inattention" is related to low levels of alertness is not known because of shortcomings of current accident reporting procedures.

Figure 1 **A "Strawman" Conceptual Model of the Attentional Problem In Driving**



The Measurement Problem

Attendees agreed that significant progress has been made in the measurement of alertness or the onset of sleepiness. EEG and EOG techniques are being developed which cause minimum disruption of operator performance.

Knipling reported on the VPI research which focused on changes in control inputs as related to drowsiness states. Rockwell reported on the NASA's transpacific alertness study which utilized EEG and EOG, as well as, a PVT (Performance Vigilance Test) to measure lapses of alertness.

Currently measurement of "inattention" or inappropriate divided attention does not seem possible probably due to lack of concise definition. Precursors to actual loss of attention are difficult, if not impossible, to measure at this time.

Smiley, in her opening remarks, suggested that drivers can maintain lateral and longitudinal control and still be cognitively out of the loop. Such conditions can result in failure to attend to traffic control devices or respond to hazardous conditions. Later she reported on the problem of sleep apnea and its possible effect on safe driving performance.

Blink rate as a predictor of drowsiness (inattention?) was discussed. While lower rates are related to the onset of drowsiness, such rates can also be indicative of intense attentional focus.

Countermeasures for Driver Alertness and Attentional Problems

Knipling introduced the role of IVHS warning devices and their potential to offset attentional problems of drivers. He couched the problem in terms of warning effectiveness in the detection of the drowsiness state in drivers. the occurrences of such epochs in driving and the likely range of false alarm rates:

THE FALSE ALARM PROBLEM

- **ASSUME:**
  - **75% DETECTION, 3% FALSE ALARM RATE**
  - **DRIVER DROWSY 1% OF THE TIME (10 of 1,000)**

System Decision/Response: Driver Status:	Activate Alarm	No Alarm
Drowsy	"Hit": 7.5 epochs	Miss: 2.5 epochs
Alert	False Alarm: 29.7 epochs	Correct Rejection: 960.3 epochs

False Alarm/Hit Ratio = 29.7/7.5 = ~4:1
(Probably an unacceptable ratio for many drivers)

The attendees concurred that other IVHS devices to reduce rear end collisions, run-off-road and backing crashes would be appropriate countermeasures for the attentional problems.

Farber presented the concerns of the auto industry, especially about the public's tolerance to any false alarm and the tort liability issue. He suggested that his estimates reveal the driver to be a very reliable controller, but one whose crash avoidance performance may still be enhanced by the use of IVHS aids.

Needed Research

A variety of suggestions for research were offered by the attendees. Some of those are listed below.

1. Better crash investigation procedures to discover precrash conditions and to breakout different causal structures related to "inattention." Particularly important is the need to determine if the driver made any attempt to avoid the crash (an indication of drowsiness not inattention).

2. Need for better operational definition of "alertness" and "attention.

3. Develop a taxonomy of alertness and attentional errors.

4. Measurement of traffic conditions - volume, speed and time headway at the time of rear end crashes.

5. How drivers will respond to IVHS warning devices.

6. How drivers will respond to IVHS induced false alarms.

7. Relation of age to the attentional issue. One of the attendees is studying the specific effects of Alzheimer's disease on driving.

8. The need for evaluation of highway design and operation and its influence on attentional related accidents. Cited as examples were rumble strips. curve warnings and the potential to measure truck weight and speed on exit ramps to provide specific warnings to prevent rollovers.

9. Need for driver model to incorporate IVHS specifications.

10. Whether IVHS warning will induce driver risk, i.e., "push on" with extended trips with the confidence of alertness warning devices.

4.5 EMERGING TRENDS IN OPERATOR PERFORMANCE MEASUREMENT

Dr. Rodger J. Koppa and Dr. R. Quinn Brackett
Texas Transportation Institute, Department of Industrial Engineering
Texas A & M University, College Station, TX

Themes of session

Measuring human performance in transportation-related systems while minimizing.

a. Interference by observational methods that can and do change actual system operator behavior.

b. Doing (a) without winding up in court (the matter of informed consent).

Measuring mental workload/resource allocation under real or simulated operational conditions, taking into account the above.

Goals of Session

To present a brief review of some recent research bearing on both themes.

To discuss technical, practical, and ethical issues of both covert and workload research methods, with a particular orientation to IVHS system design considerations.

To develop a session position paper based upon the discussion.

Session Plan

"Trigger" presentations were given with discussion by all participants. Two working groups were then formed on (1) Covert Observation, and (2) Workload Measurement. Each working group identified the major technical, practical, and ethical issues and trends in both human factors and transportation engineering related to the themes.

COVERT OBSERVATIONAL METHODS

by

Rodger J.Koppa,P.E. ,Ph.D

Background (Meister, David Heresies:- Brief Essays on Human Factors (1977)

"The results of behavioral studies performed in a non-system context cannot be automatically generalized to the personnel subsystem but must be verified by further studies in the actual or simulated system. Consequently most of the available behavioral literature cannot be accepted as descriptive of man/system performance."

"...Most of the questions raised about (human factors) data have focussed on their validity, i.e. whether the data "accurately represent what exists in the real world. Unfortunately, we have no external criterion of "truth" except the data whose validity itself remains to be verified; hence the question of data validity is strictly speaking ultimately unresolvable. At best, the researcher can collect data from alternate sources of the same phenomenon or employ different data collection methods; if data agree, he may have greater confidence in them, but this merely verifies their reliability rather than their validity. All data gathering instruments may possess a deadly flaw that prevents them from registering "truth."...if proving validity is beyond us, we might well spend more time worrying about a problem which is more solvable. That problem--relevance--is one which is particularly important to human factors, with its broad scope and goal of assisting system development.

"The reason for being concerned about relevance is that data can be valid (at least to the extent that one can determine validity) and yet completely irrelevant.

"Relevant to what? In human factors, because its major goal is to assist system development, relevant to the questions posed by that development."

Excerpt from: *Guide to Human Performance Measurements* (1992) ANSI BSR/AIAA G-035 1992 (DRAFT) V.J. Gawron, Ph.D). Chair of Life Sciences and Systems Committee on Standards

Non-intrusiveness

A measure requiring a technique that in the process of data collection attracts the attention may clearly affect the subject's task performance. If it does so, the measure is intrusive. Note that it is not the measure that is intrusive, but the method of collecting the data for that measure.

Almost all measures are intrusive to a certain extent, but their contaminating effect on task performance will vary. Under certain, very special circumstances, a data collection method will be completely nonintrusive, but these are rare. Examples are naturalistic observation when the observer is invisible to the subjects, as with a one-way vision screen; or data are collected automatically, so the subject is not aware of data collection, as in the case of computerized recording of keystrokes.

Less obtrusive methods of data collection are to be preferred to more intrusive ones. An example of a highly intrusive method is measurement of eye fixations, because this requires a camera attached to the eye.

In most test situations, the subject will be aware that his or her performance is being measured. The question to be answered by the measurement specialist is whether this awareness significantly affects what the subject does. This is, of course, a "judgement call,"

To the extent that the data-collection method does not significantly alter the context of the task being, performed (e.g., the task is not actually changed by the data collection), the method will probably not unduly affect the subject. The worst case, of course, is one in which the subject is forced to alter task performance to provide data, e.g., switching task performance to filling out a data form; this is unsupportable from a measurement standpoint.

It is noted that self-reporting measurement techniques, such as interviews and questionnaires that can be utilized <u>after</u> task performance, are not intrusive. Automatic data recording, such as audio recording and timing are also not intrusive. Video camera recording, if performed quietly, is only slightly intrusive.

When intrusion into task performance is in doubt, the investigator should consider running a preliminary study using the data-collection method. This might involve collecting a data sample with the method and asking subjects to rate intrusion, or comparing monitored performance against unmonitored performance using an independent measure.

The selection of a method of data collection is, after all, a tradeoff among competing requirements and constraints, and one may be forced against one's wishes to use a more intrusive methodology than is desirable. In making such tradeoffs, the investigator should ask the following questions:

(1) Will the subject be aware of the measuring device, of the fact that performance is being measured?

(2) If so, to what extent will the subject be aware of this?

(3) Is it reasonable to assume that performance will be significantly affected as a consequence of the data-collection method?

Issues on Operator Performance Measurement Using Covert Means

TECHNICAL:

1. In what operational context are such measures needed?
   - Psychophysical studies?
   - Perceptual-motor skills?
   - Normal operations?
   - Off-nominal/emergency
   - Problem-solving?
   - Usability/acceptability
   - Workload?
   - Vigilance?
2. Distinction between covert methods and field evaluation methods?
3. Measurement during operations vs. after-the-fact?
4. Experimental vs. quasi- experimental?
5. 3 continua:
   (A) Level of measurement (nominal to ratio)
   (B) degree of sophistication of measurement (Number segments in the scale)
   (C) Investigation:
      Subjective perception;
      objective perception;
      Active inquiry
         Indirect control of Independent Variables
         Direct control of Independent Variables
      Each level of 3 continua must be preceded by lower levels, and suffices for all that precede
6. Advances in technology:
   Videotaping
   Position and derivative sensors
   Adaptive programs
   Automatic logging of KB inputs

PRACTICAL ISSUES

1. Acceptability in research/engineering community
2. Data reduction (real-time vs. afterwards)
3. Relevance to system development (especially IVHS, legal considerations)
4. Cost of covert methods as compared to more intrusive approaches

ETHICAL ISSUES

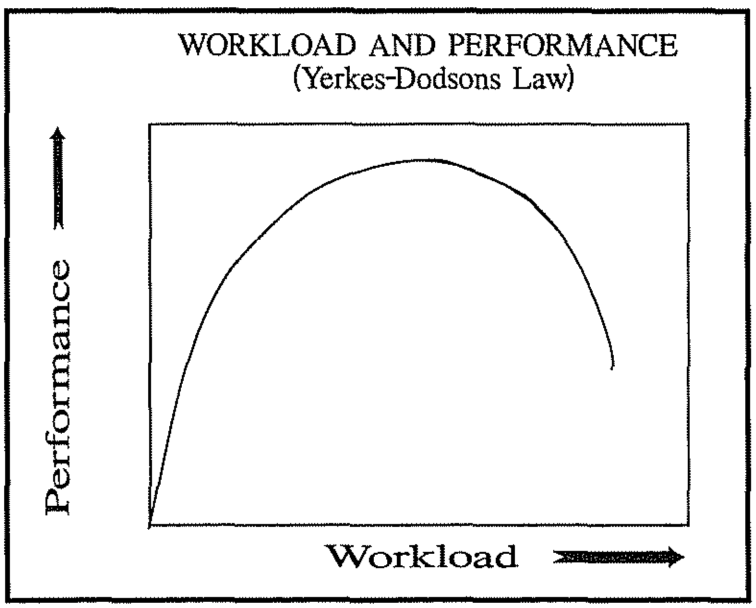
1, "Informed consent" practicability
   Before the fact
   After the fact
2. Deliberate misleading of subject
3. Quasi experimental approach vs. intervention
   Liability aspects

MEASUREMENT OF DRIVER WORKLOAD

by
Quinn Brackett, PhD

Mental Workload

"Mental workload refers to the expenditure of mental capacity required to perform a task or combination of tasks" (Venturino, 1990). It is a concept important to the design of systems that are operated and controlled by humans. Successful operation of such systems requires that mental workloads imposed on operators do not exceed their processing capacities. It is also important that mental workload levels do not fall below levels where attention-to-task requirements become difficult. In a theoretical sense, the relationship between human performance and mental workload follows the Yerkes-Dodson Law (Wildervanck, et al., 1978). This law implies a range of mental workload levels where performance is optimized:



At workload levels above and below this optimum range, performance is degraded. At high levels, performance suffers because there is too much information to process. At low levels, inattention leads to missed information and poor performance.

Measurement of mental workload and definition of processing, capacity limits is essential for identifying those tasks that overload operators such that overall system performances are degraded. Once identified, tasks can be modified to reduce workload and increase system performance. It is also important, in certain contexts, to identify those tasks that underload operators. In these situations, such as during vigilance tasks, it may be necessary to increase workload artificially to keep attention focused on the task.

Mental workload has generally been measured using subjective judgements, physiological correlates (such as increases in heart or respiratory rates, and changes in galvanic skin responses or by observing degradation in primary or secondary task performance (Eggemeier, 1990). Each of these measures has limitations. Subjective judgments, for example, are easily obtained but vary considerably among individuals due to individual differences and high correlation with task familiarity. Subjective judgments do not produce absolute measures of task workload, but do provide a means of comparison among tasks on a relative basis.

Physiological measures of mental workload are usually good measures of low workload levels or inattention. However, for measurements of high workload levels they are somewhat difficult to obtain and use. Unlike physiological measures of physical workload, which are reasonably predictable, physiological measures of mental workload are highly variable and difficult to relate to a specific task. This difficulty is the result of lags in responses and the influence of other mental activity unrelated to the task being measured.

Measurement of performance degradation on primary or secondary tasks yields the most direct and reliable measures of mental workload. According to Sender, 1970, these measurement methods assume an underlying model of information processing that suggests that the human "operator or observer is a single-channel device and that demands are made on this device by sources of information in the environment..." Thus, information is queued up by the single-channel device to be processed and the length of this queue is a measure of the potential interference when attempting to attend to two or more sources of information simultaneously.

When using only the primary task, measurements are made by increasing the information flow rate for the task until performance falls off. In this case, information enters the processing queue faster than the single-channel operator can process it. This method provides an estimate of the mental capacity required for performing the task. It could also be interpreted as the 100 percent workload level. Unless the relationship is linear, however, reducing the information flow rate by 50 percent does not necessarily mean the mental workload is correspondingly reduced.

Performance degradation on a secondary task, one unrelated to primary task performance, provides a measurement of spare mental capacity. It is assumed that the change in performance on the secondary task in the absence and in the presence of the primary task represents the mental workload demanded by the primary task (Knowles, 1990). Thus, a reduction in performance of the secondary task of 40 percentage points indicates that the primary task required 40 percent of the mental capacity or a 40 percent workload level.

The difficulties with using secondary task methods of measurement are that they distract from the primary task if they are totally unrelated. The secondary task can cause inflated estimates of workload due to additional mental processing capacity required to make the transition from the primary to the secondary task, or because the operator becomes so absorbed in the primary task that the operator neglects the secondary task completely.

A variant on the performance measurement mental workload is the information storage method. Rather than using a secondary task, an operator is allowed to control the presence of primary task information (Williges and Wierwille, 1979). The flow of information about the primary task is not altered, merely the receiver's access. In a measurement of this sort, the operator voluntarily controls the presence or absence of primary task information. When not receiving information about the task, the operator relies on the integration of information previously received to make predictions concerning the performance requirements of the future. Assuming-error free task performance, then the percentage time of information use relative to the total time information was available provides an estimate of mental workload:

$$\text{MENTAL WORKLOAD (in percent)} = \frac{\text{ACCESS TIME}}{\text{TOTAL TIME}} \times 100$$

Driver Workload

The highway system with its components of driver, vehicle, roadway, and environment, is sufficiently complex to raise concerns about workloads imposed on drivers. Certainly, one concern would be the need to keep workloads levels high enough to prevent driver inattention or sleep. The other concern would be that of overloading drivers. In the latter case, there are several tasks drivers perform that warrant examination from an overload standpoint. First among these tasks would be that of control. This task involves controlling the vehicle such that collisions with other vehicles, pedestrians,and other objects in the roadway are avoided. A less critical, but important task is that of processing information for navigational purposes. A third task, and one of particular concern to roadway design engineers, is that of guiding the vehicle on the roadway path (Alexander and Lunenfeld, 1986). This task is the focus of this project,

A driver extracts specific information from the environment in order to successfully guide a vehicle along a particular path. The information extracted pertains to the orientation or direction of the path or roadway to be followed and the position of the vehicle relative to the path. Direction information can be provided by the roadway itself, delineation devices associated with the roadway, traffic on or near the roadway, and the roadside environment. Position information is provided by the hood of the vehicle viewed in relation to the edge(s) of the roadway to be followed.

Processing capacity allocated to the guidance task depends upon estimations of the mental workload that will be imposed by the roadway path and conditions ahead. The higher the estimate of mental workload demand, the greater the attention or capacity allocated to the task. Workload estimates will vary as a function of vehicle, vehicle speed, traffic, and roadway geometry. These estimates will also vary as a function of individual differences in ability, expectancy, and experience, and on physiological and psychological state or condition.

Underestimating the mental workload requirements of the guidance task can result in errors and, possibly, crashes. Underestimating can occur when drivers, through lack of experience, fail to recognize characteristics of the roadway that require greater attention, when experienced drivers expect a lower workload than is required, when a driver's information processing abilities are impaired, or when a driver's attention is distracted from the guidance task, such that the stream of information upon which workload projections are based is interrupted.

Drivers manage guidance workload in one of two ways. First is by allocating more attention or capacity to the task by fixating on the road geometry, particularly during curve negotiation (Shinar, 1977, Mourant, 1969). The second is by reducing speed, thereby reducing information flow rates and increasing time available to process information. Both of these actions require the driver to recognize the workload demand imposed by the roadway ahead. Accurate recognition is facilitated by consistently designed roadway geometry. It is the contribution of roadway geometry to the workload associated with the guidance task that is of particular interest in this project.

Measuring Driver Workload

Like workload in other contexts, driver workload has been measured using subjective appraisals, physiological measures, and by measuring changes in performance on tasks secondary to the primary task of driving (Messer et al. 1979, Wildervanck et al., I978, and Ogden et al., 1979). Another approach has been used that is similar to the information storage technique described in the preceding section. This approach involves drivers voluntarily occluding their vision, opening their eyes only when they think it necessary to extract information necessary for guidance (Godthelp 1984, Farber and Gallagher, 1972, Shinar, 1978). According to Williges and Wierwille, 1979, in this approach, "The assumption is made that the driver's attention is only intermittently on the road.

Between observations of the road, the driver approaches a threshold of uncertainty concerning the placement of his/her own as well as other vehicles on the road. When this threshold of uncertainty is reached, the driver once again observes the road."

Logically, if vehicle speed is constant and lane integrity is not violated, then the amount of time that drivers are unwilling to have their vision occluded, over a fixed length of roadway, represents the mental workload required for the guidance task for that particular stretch of road. The lower the information processing capacity requirements of the roadway, the longer the time drivers will keep their eyes occluded. Conversely, the greater the capacity requirement, the greater the amount of time a driver will need to look at the roadway and the higher the level of mental workload.

Zwahlen, in 1974, performed a study that described the limits of occluded vision driving. He asked subjects to drive with their eyes closed and measured lateral deviation of their vehicles. He found that without visual input, on a flat road surface, deviations of 20 inches occurred after 300 feet of travel distance. At 30 mph, these deviations equate to more than seven seconds. Deviations of 20 inches occurred sooner for drivers operating at lower speeds and for drivers who had no steering input capability.

Studies conducted by Rackoff in 1975 and Shinar et al. in 1978 indicated that when drivers voluntarily occlude their vision while driving, older drivers require more "eyes-open" time to extract information than young drivers. Rackoff found the mean "eyes-open" time to be 2.03 seconds for older drivers (ages 60-70) and 0.72 seconds for younger drivers (ages 21-29). In the study by Shinar, et al., the mean "eyes-open" time for older drivers (ages 63-70) was 1.5 seconds and for young drivers (aged 20-25) 0.7 seconds. These studies also suggested that older drivers were more field dependent and consequently took more time to disembed important information from the driving environment.

The visual occlusion concept was discussed as part of a model for driving behavior introduced by Godthelp, Milgram, and Blaauw in 1984. In the results reported, voluntary occlusion time for drivers was shown to vary as a function of vehicle speed (from an average of more than 5 seconds at 12 mph (20 km/h) to less than 2.5 seconds at 60 mph (100 km/h). The research also introduced a measure of driving performance called "time to lane crossing (TLC)". This variable represents the projected time from the vehicle's present position to crossing either the centerline or edgeline if no corrective steering action is taken. The sum of the occlusion time and the TLC remaining after the occlusion interval represents total time available for guidance. The ratio of occlusion time to this sum represents the proportion of spare visual capacity. According to the authors, this ratio is almost a constant 40 percent when measured on a tangent roadway with no opposing traffic. The complement of spare visual capacity would be an estimate of mental workload, in this case approximately 60 percent. Subsequent research by Godthelp and Kappler, 1988, suggests that the spare visual capacity ratio (and, therefore, workload) may vary slightly with the handling characteristics of the vehicle (degree of under or oversteering).

In order for the spare visual capacity to remain constant under different demand levels, either speeds or occlusion time must change. Indeed, Van Der Horst and Godthelp, in 1989, reported that as lane widths were reduced from 3.55 meters to 2.05 meters, voluntary occlusion time decreased. Further, as vehicle speed increased for any given lane width, occlusion time decreased. Further, as vehicle speed increased for any given lane width, occlusion time decreased (see Table 1.). Thus it would appear that voluntary occlusion time could serve as a sensitive measure of the workload requirements of various geometric characteristics of the roadway.

TABLE 1. OCCLUSION TIME (in sec), LANE WIDTH AND SPEED

SPEED		LANE WIDTH (feet)		
(mph)	6.73	8.37	10.0	11.65
12.45	2.4	3.6	3.8	4.3
37.35	1.4	2.0	2.5	2.9
62.27	.09	1.4	1.9	2.1

* After Vander Horst and Godthelp, 1989.

Conclusions from Workshop

Covert Observational Methods

- o Should be called "non-intrusive" methods
- o Degree of intrusion on a continuum
- o Time at which measurements made has great influence on practicality of non-intrusive measures; after-the-fact observations cannot influence performance
- o Cost of non-intrusive measurements may be prohibitive
- o No general conclusions regarding use of non-intrusive methods "It depends!"
- o No new techniques for extracting human performance data without subject awareness identified
- o Attendees at session agreed to concentrate on workload measures

Workload Measurement

o Basic Four Approaches:
  Primary Task Measurement
  Secondary Task Measurement
  Subjective Evaluation
  Physiological Measurement
o Indicant Methods:
  (Access to primary information/total task time) x 100
  "Perception of Workload"
  Increase frequency of critical conditions
o Workload is task specific
o A possibly unnecessary construct from measures
o Figure of Merit for task is more important than work:load as such
o Some new/different techniques for measuring/indicating/inferring "workload":

1. Voice analysis, using fourier techniques

2. 200 lead EEG suitable for field measurements (subject must wear football helmet)

3. Eyeblink interval measurements

4. Talk-through approaches; subject trained to verbalize task loading

5. Single-incident approach; subject used only once at a critical level of load

6. Usability laboratory (quasi-covert methods)

7. Information deprivation: the higher the workload, the higher the available information must be to achieve desired performance

4.6 CAN DRIVERS USE IVHS: A PRACTICUM IN DEVELOPMENT AND TESTING DRIVER INTERFACES

Dr. Paul Green, Human Factors Division and Industrial and Operations Engineering, University of Michigan, Transportation Research Institute, Ann Arbor, MI

Purpose and Process

The purpose of this workshop was to

(1) convince people that rapid prototyping is an essential part of driver interface development and

(2) teach them how to use SuperCard, a commonly used Macintosh application for prototyping.

The University of Michigan, Transportation Research Institute (UMTRI) currently has a DOT-funded project to design and evaluate a variety of advanced driver information systems. That effort has reinforced the dual importance of good human factors data and iterative design. For iterative design to occur, tools are needed that allow the rapid prototyping and testing of user interfaces. This workshop examined one tool for that purpose.

The session began with the participants introducing themselves. Dr. Paul Green led the session with assistance from Ms. Marie Williams of UMTRI. In addition to Ms. Williams and Dr. Green, there were 11 people who stayed for the entire exercise. About half of them had human factors expertise and half had some Macintosh experience. Participants split into five groups that distributed expertise.

Subsequently, Dr. Green described the problem they were to address, the development of an easy to use interface for entering information into an advanced driver information system. Information of interest included addresses for the navigation system (number, street, and city), roads for the traffic information system, and phone numbers for the cellular phone. The basic interface was to be an enhanced phone keypad which could either be on a phone handset or a touchscreen. This constraint results from real limitations of cost or instrument panel real estate.

After Dr. Green reviewed the Gould and Lewis work on interface design and four papers concerning human factors and the interfaces of interest, the session focused on teaching prototyping. Working with Ms. Williams, Dr. Green taught participants how to use SuperCard. The general procedure involved demonstrating a few concepts (e.g., buttons and fields), giving participants a brief exercise to carry out (e.g., create a button and make it display a digit each time it is pressed), and then covering the next topic. Coverage of the language concepts included scripts, the SuperCard equivalent of subroutines.

Participants spent the beginning of the afternoon selecting an interface to design and most of the afternoon implementing it. By the end of the session, one group had a working interface and the others were within a hour of such.

At the very end, each group demonstrated their design to the others. Participants were surprised as to the variety of implementations. Their questions indicated they were convinced they should utilize the prototyping tools presented. ("How much does the software cost? Which model Macintosh should I buy?") Given these reactions and the progress participants made in developing prototypes, it appears the workshop session achieved its goals. In the process, participants also had fun.

Further details concerning the session are in the attached notes given to each session participant. More time was actually spent on teaching SuperCard than is shown in the schedule, and as a consequence, somewhat less was spent on prototyping each interface.

Description of the problem - Design and Evaluation of an Input Device

Your task is to design and evaluate a shared generic alphanumeric input device for IVHS interfaces. This device will be used for entering phone numbers into the cellular phone, destinations for the route guidance system, routes of interest for the traffic information system, place names into the yellow pages, and so forth.

It has already been decided hard keys will be used and they must fit into a 4 inch by 3 inch area, which you will simulate using a 5-inch diagonal display (actually a 5-inch section of a larger display). It is a high resolution display (NTSC) and the touch sensor is very sensitive, so do not be concerned about display resolution or touch resolution issues. For reasons of legibility characters must be 1/4 inch high (18 point) or larger though in unusual cases it may be possible to get a waive to use .2 inch high (1 4 point) characters.

Your task is to select an entry method for alphanumeric information, develop the logic, and format the display. Do not worry about how one gets to these screens. Someone else will design the screens to select each susbsystem (phone, traffic information, etc.). and put the user in the proper mode (dial, route selection, etc.).

Each screen will have the following items on it. Since all entries are upper case, shift and case lock should not be provided.

Display fields:

1. a display window for an instruction (e.g., Enter first 4 letters of street address)
2. *a display window for the characters entered* (e.g., GREE)

Keys:

1. delete last keypress
2. enter
3. go back (to previous screen)
4. 12 keys on a phone (for your info: 9.5 mm square, 16.5 mm center to center)

1	ABC/2	DEF/3
GHI/4	JKU5	MNO/6
PRS/7	TUV/8	WXYI9
*	Oper/0	#

5. Other mode keys you may add (described in the section that follows) along with a clear entry key

Entry Logics

Following is a partial listing of the entry logics:

1. Letter position methods
    a. select mode (alpha or numeric)
        options-special keys for alpha and numeric
            special alpha key, # for numeric
            special alpha key, if no key hit defaults to numeric
            others
    b. select letter
        options-hit L,M, R (5, 6, 7) to select Left, middle, right character
            then key with triple of interest (e.g., 5, 2 *would select left of* ABC/2 or A), use 1, 2, 3 to select left, middle, and right
            dedicated left, middle, and right keys (instead of using 5,6,7)
            multiple press-after selecting mode,1 press selects left character, 2 presses select the middle, 3 presses select the right; so to select C on the ABC/2 key one would press 222.
2. Direct position method
    a. select position directly
        option-4 keys: number, alpha left, alpha middle, alpha right
            press one
    b. select desired key
3. Other schemes

Design tradeoffs and issues

1. number of keys vs. key sizes vs. number of key presses required vs. number of keys to search though
2. logical sequence - mode then desired key vs. desired key then mode
For example, in the direct position method one could press alpha-left then 2 to select an A or, 2 and then alpha-left.
3. Should the entire sequence be keyed in or should the system do something when it matches the data base?
4. What kind of errors are likely and how should feedback be provide?
5. Should keying feedback be provide? after each keystroke? after each character entry? after each field entry?
6. If feedback is provided should it be visual, auditory, or a combination?
7. How should characters (Q, apostrophe, Z, hyphen, space) not on the keypad be handled? (ignore, use another character that is similar (O-Q), use *, #, add keys, etc.)

Deliverable (3:10PM):
5-minute presentation showing working interface
and describing what was learned from the development effort and user tests

Pilot Test of Interface Design

The purpose of this experiment is to test the safety and ease of use of device for entering text into an information system that might appear in cars for the future. This includes phone numbers, addresses for where you might want to go so the car can give you directions, roads you might plan to travel on (to find out about the traffic), and so forth. The focus of this experiment is on the system, and this system is being designed for you, so if there are problems, they are the designer's fault, not yours.

For this experiment numbers and letters will be entered into the computer using the mouse In a real car a touch screen would be used. but there aren't any handy now. When the experimenter says go, key in the phone numbers listed below and then stop. Key them in as you normally would. (The experimenter will say "go" and start a stop watch, stopping it when the list is entered.)

Phone numbers	*Routes*	*Addresses*
936-1081	194	2394 Main St,Ann Arbor
764 4158	1696	34981 Gratiot Blvd, Detroit
665 9272	US12	1 2B Fernando, St Louis
747 8799	M14	1 Mississippi Ave, Pensacola
764 6504	US1	19 Lois Lane, Philadelphia
366 1923	495	407th Street, Washington
STOP!	STOP!	STOP!

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HyperCard manuals are more useful for most programming

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4.7 HIGHWAY WORK ZONES: INTEGRATION OF HUMAN FACTORS INTO THE MUTCD

Mr. Jerry L. Graham, Graham-Migletz Enterprises, Inc.
Independence, MO

The need to consider human factors in the development of new traffic control devices was discussed in this session. After a short statement of the objectives of the session, 20 participants introduced themselves. The participants included human factors engineers, traffic engineers, device manufacturers, and state government engineers who use new traffic control devices.Participants had varied backgrounds including several members of the National Committee on Traffic Control Devices, a researcher who had traced the evolution of the MUTCD, and two Canadian representatives who had worked with various aspects of the Canadian MUTCD.

After the introductions, Jerry Graham discussed innovation. Innovation is always present in the field as new devices are developed to make a job safer, easier, or faster. The amount of innovation that is actually put into practice has to do with the attitudes and policies of industry, government, and drivers.

Innovation is "risky" and may result in traffic controls that are worse than old devices if human factors criteria are not considered in the development of new devices.

A video developed for the AAA Foundation for Traffic Safety by Graham-Migletz Enterprises entitled "Getting Safely Past The Orange Barrels" was then viewed and discussed. The video presented driving tips for getting safely through work zones. The lack of driver knowledge concerning work zone traffic controls was discussed. Two items discussed in particular were the meaning of diagonal stripes on barricades and the arrow panel "caution" mode. The devices and applications that required a certain amount of driver knowledge were contrasted with "intuitive" devices, such as arrows that give drivers a clear indication of the action required.

The experimentation process in the MUTCD was then discussed. The point was made that in some industries a new device is on the market within 18 months of its inception. This time period is contrasted with the average MUTCD revision of every ten years. To many participants, this pointed to the inadequacy of the MUTCD process for developing new devices; however, another group of participants felt the MUTCD process included a wide range of experts and was the best process available for approving new devices.

After lunch, Fred Hanscom discussed the Strategic Highway Research Program (SHRP) that was designed to develop and test a number of new work zone safety devices. Closed track human factors studies were made utilizing a closed airport runway and an instrumented vehicle. Two of the tested devices were displayed in the session and a SHRP product catalog was given to each participant. Subsequent open-highway testing of some of the devices, permission to experiment, and results of limited field tests were also discussed. Three of the devices had been presented to the Construction and Maintenance Committee of the NCUTCD, but no action had been taken on these devices.

Gerry Alexander then discussed the human factors criteria for a successful device. He discussed the five basic requirements for traffic control devices listed in the MUTCD:

* Fulfill a need
* Command attention
* Convey a clear, simple meaning
* Command respect and
* Give adequate time for response

He also discussed seven basic human factors requirements that closely parallel the MUTCD requirements:

* Clear and simple
* Conspicuous
* Legible
* Obvious meaning
* Not too much, not too little
* Credible
* Unambiguous

He discussed the workings of the NCUTCD and stated that a large number of very knowledgeable people donate time to give a full and fair review of what goes into the MUTCD. He also pointed out that only two states have any human factors expertise on their staff and that there is a serious need for more human factors expertise in the application of traffic control devices.

There was a great deal of discussion during these presentations concerning many issues, including:

a. The new Part VI is too long.

b. In Canada, there are separate Office and Field Function manuals.

c. It is very difficult to change what is already in the manual.

4.8 STATISTICAL METHODS IN TRANSPORTATION RESEARCH: PITFALLS, MISUSES, AND HOW TO AVOID THEM

Dr. Olga J. Pendleton, Materials Division, Texas Transportation Institute, The Texas A & M University System, College Station, TX

This workshop was an extension of an earlier workshop presented In 1988. There were 30 participants including two international members from New Zealand and Finland. Various state and federal agencies were represented.

The workshop format was more on the order of a tutorial although there was quite a bit of interaction from the participants. The main emphasis in the workshop was the presentation of statistical misuses in transportation research and remedial measures for correcting them. Examples were drawn from the session leader's ten years of experience in the area of transportation statistics and were based on actual published research results.

The session began with the more traditional statistical methods of regression and analysis of variance. Examples included cases of miscoding regression variables, over fitting models, constraining models and misinterpreting results. The workshop also focused on new methods for indentifying data problems and the current computer software available for implementing these methods. These methods included indentifying collinearity problems, diagnostics for influential observations, and the interpretation of analysis of variance results with unbalanced or missing data. Other traditional methods taught were covered included experimental design problems and the repeated measures problem.

Additional topics were presented in this workshop that were not covered in the 1988 workshop. These included a review of existing methods in highway safety evaluations using accident data and an update on the current research in this area. Two other new topics were the analysis of categorical data using log-linear modeling and logistic regression. Instructions for implementing these procedures using SAS and interpretation of the computer output and results were also included in this workshop.

The workshop was videotaped and will possibly be available for distribution through TRB. A discussion of some potential follow-on workshops produced the following recommendations:

1. A workshop on existing computer software for statistical analysis including hands-on demonstrations with PC's.

2. A workshop session on TQM - Quality Control methodologies for transportation research.

5. HUMAN ERROR CAUSED ACCIDENTS - DETERMINING OPERATOR FITNESS FOR DUTY

Dr. Anthony C. Stein, Presiding, Systems Technology, Inc.
Hawthorne, CA

TRB Session 40 was held in the afternoon on Monday January 11, 1993. The Session focused on the determination of operator fitness for duty, one of the key problem areas for transportation safety as well as for safety in other industries.

Human factors research has brought forth a far greater understanding of the human and his capabilities. Determining whether an individual is prone to making an error because of impairments of any kind including drugs, alcohol, physical problems, fatigue, boredom, or any other type of impairment remains an important issue to safety. Progress is being made, however, in understanding and defining these issues and in developing and implementing both detection and prevention methodologies as well as methodologies to cope with and ameliorate the impairment effects on the operator's performance. Some of the progress in this area is reported in the presentations that follow. Several of the human factors Workshop Session reports (Presented in Section 4 of this Proceedings) were also given during this TRB Session.

5.1 AN INTRODUCTION TO FITNESS FOR DUTY

Mr. Jerry Wachtell, U.S. Nuclear Regulatory Commission, Washington, DC, and The Design Eye Group, Baltimore, Maryland

It is difficult to provide in a brief overview, a reasonable introduction to the subject of fitness for duty. Perhaps I have been asked to provide the introductory remarks because my views on this subject are somewhat different than most; I believe that the concept of fitness for duty held by many of my colleagues is too narrow. By that I mean this: People that I come in contact with in my work in both the nuclear and transportation fields (power plant operators and maintenance workers, licensing examiners, motor vehicle, administrators, and law enforcement personnel, for example) seem to believe that fitness for duty should be defined as some measurable degree of *substance abuse* (generally alcohol and illegal drugs - although prescription and over the counter drugs are occasionally included); and that this abuse should be punished.

In contrast, I believe that, although substance abuse may be a major factor in a given individual's temporary inability to perform his or her job, and that willful violations of the law should be dealt with appropriately, fitness for duty is a much broader concept than substance abuse alone. I believe that a lack of "fitness for duty" can be due to fatigue, a common cold, a medical condition such as sleep apnea, or other personal factors which may result in temporary stress or distraction. I further believe that, because these factors have traditionally been difficult to define and measure, no less to relate to performance decrements, we have tended to take the "easy way out" by defining fitness for duty in more readily quantifiable ways.

The question, to me, is this: if an individual has job responsibilities where public health and safety is at stake - and on a given day performs below par because he or she has a cold, or stayed out and partied too late the night before, or has had a fight with a loved one before leaving home, shouldn't that person be considered unfit for duty on that day or during that shift? Shouldn't that person's manager remove him or her from duty when safety (of the public or the worker) is at risk, perhaps temporarily reassigning the worker to another task? (Better yet, shouldn't the individual remove himself)?

This discussion of sub-par performance makes two important assumptions first, that the individual is qualified to do the job in the first place - and second, that we can somehow determine when performance falls below a minimally acceptable level (which, may or may not be the same as that individual's baseline performance).

In contrast, much of our current fitness for duty testing is based on other criteria. Although our DUI limits, for example, are based on a wealth of accumulated empirical data and are therefore enforceable in the courts, we all know of cases in which someone could perform adequately despite having a blood-alcohol level far higher than the legal limit. Our random drug testing is even more troubling to me as a fitness for duty measure. Although we have established precise cut-off levels for each of many drugs for which we test, we have a less than precise understanding of the impact of these levels on operator performance. It seems to me that our focus should properly be on that performance, and less on chemical tests.

Let me discuss two generic situations in which fitness for duty is mediated by factors other than substance abuse. In some cases it is the job itself and the circumstances under which it must be performed that challenge a worker's fitness for duty. Take shift work, for example. Through the years the research community has developed a good understanding of the effects of shift schedules and shift rotation on human performance. The data indicate that we can expect certain performance decrements to occur at certain times of day and at certain points in a shift. In part as a result of such research, the Federal Aviation Administration (FAA) now permits, under closely circumscribed conditions, members of commercial flight crews to sleep during trans-oceanic flights. The Nuclear Regulatory Commission (NRC) has taken a different approach to the problem of fitness for duty related to shift schedules. In essence, there are no regulations governing shift schedules at U.S. nuclear power plants. There are, however, regulations which prohibit sleeping in the control room of a nuclear power plant on shift, and related policies which prohibit the presence of "distractors" in the control room- books, magazines, radios, etc. The prohibition against such "distractions", combined with shift schedules that may be less than optimum and a work environment that often promotes boredom and requires vigilance (at least when the plant is running normally at full power), seems contrary to efforts to sustain high levels of operator alertness. Even if operators are not technically asleep under such challenging circumstances, one may question their "fitness for duty" at any given moment - due, perhaps to no fault of their own, but rather to a work environment not conducive to optimum performance. The irony of this situation, as experts in the field of human performance have pointed out, is that, since there are *rules* against sleeping in the control room, operators and supervisors, if caught, may be punished for the very behavior that the work conditions help to promote. In short, appropriate, timely, job related measures of fitness for duty might indicate the nature of this problem, and might lead the commercial nuclear industry to address it by examining the nature of the job itself, and the circumstances under which it is performed. Traditional fitness for duty programs can provide no insights into this problem.

As a second example, let us examine a fitness for duty scenario on the highway. Typically, when a police officer stops a motorist because of erratic driving, the officer will perform a series of roadside sobriety tests - a somewhat subjective fitness for duty evaluation. If the evidence indicates to the officer that the driver is not under the influence, the officer may well allow the motorist to go on his or her way, perhaps with an admonition to drive safely. But a driver's ability to touch his nose or walk a straight line, while perhaps a good indicator of DUI, is probably *not* a good indicator of an individual's "fitness" to drive, if this lack of fitness may be due to fatigue, flu, marital discord or job pressure. The irony here is that the trained police officer probably had *just cause to* stop that driver in the first place, and there is every reason to believe that the motorist's observed erratic performance will not be "corrected" as a result of the traffic stop. If society's interest is in highway safety, should it matter whether a motorist is behaving erratically because he or she is drunk, drugged, angry, fatigued, or legally medicated? If the preliminary evidence (in this case the police officer's observation) indicates that the motorist is unfit to drive at that time, shouldn't the confirmatory roadside test measure more than one aspect of fitness for duty? Shouldn't it measure factors which are closely related to driving performance?

In my opinion, we will not make serious progress in workplace or transportation safety until we recognize that: (a) a lack of fitness for duty may be due to a wide variety of factors; (b) a measured lack of fitness on a given day may be legitimate grounds for removing the worker from the job or the operator from the vehicle on that day *regardless of root cause* (but that such removal should not necessarily be associated with punishment); and (c) the root cause must be sought, not only in cases where substance abuse is to blame, but where job-related conditions may be contributors. To accomplish these objectives, we must get a better handle on true performance testing against previously determined and validated performance baselines.

In summary, what I have been trying to say is this. In my opinion, fitness for duty is *a performance issue* - and testing should be *performance testing at a* time and place, and in a manner most closely related to the required job performance. Don't get me wrong. Tests for drugs and alcohol are important and necessary. They should continue to be refined and used under appropriate circumstances. But they are not sufficient. Better measures of fitness for duty are moving from the research laboratory to the workplace, and their further improvement and use should be encouraged. We must begin to consider substance abuse and its measurement as a *subset* of performance-based fitness for duty testing - not the other way around.

This is a very exciting research area. Many breakthroughs are being made - I hope that more are to come.

5.2 COMMERCIAL DRIVER FITNESS QUALIFICATIONS: PROTOTYPE MEDICAL REVIEW PROGRAMS

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Background

Driver licensing agencies, by statute, have the responsibility to monitor drivers and to restrict or revoke the driving privilege of those who present an unwarranted risk to themselves and to others on the highway. Implicit in this mandate are matters of policy and practice that are subject to wide interpretation and implementation. These interpretations depend to some extent upon how the driver licensing agency answers the question of which drivers are an unwarranted risk or how their limitations should be assessed.

Added to this are the Federal Highway Administration's regulations for commercial drivers. The Commercial Motor Vehicle Safety Act (CMVSA) of 1986 established the Commercial Driver's License (CDL). Under this law, a commercial driver* can hold only one license and must meet certain specified qualifications of knowledge and skill. In addition, drivers who operate or expect to operate in interstate or foreign commerce are subject to compliance with Part 391 of the FMCSRs, which requires these drivers to be medically examined every two years and to be certified by a physician that they meet certain specified medical standards.

Historical Basis for Medical Guidelines

What constitutes a medically unfit driver? How can the risk of a medically unfit driver be assessed? When should a medically unfit driver be restricted? To answer the first two questions requires medical standards that are founded on both experimental and empirical data. To answer the third question requires a screening and licensing program that is not only grounded in these data, but also enjoys political support, through legislation or regulation, to limit driving by drivers who do not meet certain standards.

There is still comparatively little extant scientific and epidemiological data to document the importance of medical impairment as a contributing factor to road crashes. These data are very difficult to collect. First, funds are generally not available for conducting long term prospective studies of drivers with

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* A commercial driver is defined as a driver who operates a commercial motor vehicle or combination of motor vehicles that: (a) weighs 26,001 pounds or more gvwr (this includes a towed unit of more than 10,000 pounds); (b) is designed to transport 16 or more passengers, including the driver; or (c) transports hazardous materials and is required to be placarded for such purpose.

identified conditions or diseases that may impair their driving. Second, even if such studies were possible, the conclusions could be biased because drivers identified as having a problem may be in a treatment program, may voluntarily limit or alter their driving exposure, or may otherwise confound any study conclusion. Third, a scientific basis for determining at what cut-off point a specific condition becomes an unacceptable risk cannot always be determined in isolation, and often not without considering other factors. For example, how well the patient compensates for a condition is one factor. Age may be another. Fourth, the aggregate or synergistic effect of more than one medical condition must be considered. This is especially relevant in the aging process - many persons will have reduced vision and may also have other medical conditions. Single conditions may not be impairing, but the combination may present an unacceptable risk. Fifth, certain medical conditions may become aggravated due to stress or fatigue, and therefore may become unacceptable risks only under certain circumstances.For these and other reasons, medical standards have evolved over the years based almost entirely on empirical evidence and clinical experience rather than on rigid scientific methods of experimentation, analysis and evaluation.

Despite these drawbacks to quantifying the role of medical impairment in driving, the licensing agency must establish regulations governing the safe operation of motor vehicles. Similarly, the Federal Highway Administration currently has the responsibility to regulate fitness of commercial drivers under its domain. Part 391 of the Federal Motor Carrier Safety Regulations (FMCSRs) is the FHWA's current medical fitness regulations. The FHWA's approach to medical fitness requirements has been generally prohibitive. For example, persons with any medical history and/or clinical diagnosis of certain metabolic, cardiovascular, neurological or musculoskeletal disease or condition are barred from driving in interstate or foreign commerce. The recent legislation establishing the CDL, and its interpretation into new regulations, provides an opportunity for the federal and state responsibilities for medical fitness qualifications for commercial drivers to converge. With the institution of the Commercial Driver License (CDL), the FHWA's goal is to require or allow states to be responsible for reviewing and assessing CMV drivers' medical qualifications. The FHWA would retain authority over the medical requirements per se, but the states would adopt and implement procedures to determine medical fitness within their current licensing/medical review structure. Eventually, the license issued by the state would be prima facie evidence of fitness to drive.

A number of initiatives are underway to address both the administrative medical review process and the medical standards. One of these is described.

Medical Review Process

In October 1990, a project titled Prototype State Medical Review Program was initiated, under contract with the Federal Highway Administration, by the Association for the Advancement of Automotive Medicine, in cooperation with the American Association of Motor Vehicle Administrators. The purpose of this project is to develop the administrative framework either to integrate CMV driver medical review procedures into state licensing systems by building upon the medical review infrastructures that currently exist for private vehicle drivers, or to develop programs from which states with no or minimal programs in place can choose to accomplish this goal. The project consists of five tasks, as follows:

Phase 1

A. collection and categorization of information about current medical review programs;

B. development of minimum administrative criteria to be met by medical review programs;

C. development of prototype programs to operate within several different types of licensing/medical review infrastructures:

Phase II

D. pilot testing the prototypes in several states; and

E. evaluation of each pilot to determine its overall feasibility and applicability across states.

In Task A, detailed information on current state medical review programs was available for review from a number of sources. From these materials, it was determined that 47 states (includes the District of Columbia) had some medical review procedures in place within the driver licensing agency; 4 states had no medical input. The size and scope of the medical program varied substantially from one moderately trained non-medical administrative staff to 137 driver improvement analysts with support staff to full time medical advisers. Thirty five states reported having a medical advisory board, and of these, 29 had medical review units. Almost half the states reported having a permanently staffed medical review program, with access to independent medical advisors on some regular basis. In general, a range of states seemed to have some existing infrastructure to screen for medical fitness to drive.

Our investigation of available information yielded some general observations and findings specific to commercial drivers, as follows:

1. Confusion and lack of understanding was apparent in some states about the medical regulations under Part 391.

2. Some states view Part 391 certification as totally an enforcement issue in which the state licensing agency has little or no part to play. In a few other states, the commercial driver medical certification process was characterized as a matter between the driver and the motor carrier, or the driver and the examining physician.

3. With regard to the driver-physician relationship, some states rely totally upon the physician's examination, without proof that physicians understand the relationship between the driving task and functional capability. In a few cases, physicians are even asked whether the driver should be licensed.

4. In the vast majority of cases, drivers subject to Part 391 self certify simply by telling the DMV that they meet the medical qualifications for interstate driving. No proof is required, and except for a few cases, drivers do not have to submit any documentation to the DMV. Licensing agencies seem to assume that interstate drivers comply if they say they do.

5. Where medical waivers exist for intrastate drivers, they involve the following medical conditions: diabetes, epilepsy, vision and hearing limitations, and limb impairments. In most states, if a driver does not meet Part 391, but demonstrates functional capability to operate the vehicle he is driving and has been medically certified by his physician, that driver will be licensed for intrastate driving only.

6. Driver licenses examiners have considerable latitude in deciding fitness to drive. The level of training that license examiners receive for screening applicants is unclear.

7. In a few states, there seems to be resistance to having the state assume the responsibility for medical certification for interstate driving. In several other states, DMV officials are quite keen to take on the process because they believe that medical certification of all drivers should be part of the licensing process.

8. Extensive exemptions from compliance with fitness requirements that are allowed by law exist in some states. While these involve only intrastate drivers, the licensing officials felt that the entire commercial driver licensing and qualifications area was affected adversely by these exemption practices.

As part of this project, a Committee of States was appointed to establish minimum administrative criteria for state medical review programs and to develop prototype programs to be tested. Initially, 10 states expressed interest in becoming pilots. Three of these states -- Arizona, Indiana and Utah -- have signed cooperative agreements with the FHWA (Arizona and Utah are operational), and several others are developing or have submitted proposals for funding. The pilot programs are funded for one year.

After the pilots are completed, they will be evaluated. Following that, and hopefully in line with FHWA's zero base medical guidelines review, rulemaking will begin that could culminate in a regulation that turns the process over to the States. During the rulemaking, views will be solicited about the various administrative aspects of the medical review process, such as what minimum standards such a program should meet, and the appropriateness of a two year versus a longer review cycle.

Pilot States

Following are brief summaries of the three pilot programs approved and/or started:

Arizona - The state DMV will collect the physical examination long form and issue the medical card. A medical review unit will be established to conduct the program and to monitor the long forms. A physician education program will be implemented in cooperation with the state medical society. The pilot is also considering a program to certify physician examiners.

Indiana - This pilot will require submission of the medical long form to the Bureau of Motor Vehicles. The medical form will be modified to include the examining physician's state license identification number and the driver's signature. A random audit will be conducted to determine physician authenticity. It is anticipated that enforcement checks can be made on the existence of medical cards. An educational program for physicians is also planned.

Utah - Utah's pilot program will be meshed with its existing medical assessment program in place since 1981. Utah uses a Functional Ability Evaluation (FAE), which requires the examining physician to check the appropriate level of severity of any existing medical condition, and leaves the responsibility for licensure to the motor vehicle agency. The Federal Motor Carrier Safety Regulations will be integrated into the FAE profile. The agency and not the examining physician will issue the medical card after review of the profile (i.e., FAE).

FHWA Waiver Programs

As stated earlier, the FMCSRs currently contain several absolute prohibitions that prevent driving by persons with certain medical conditions. While FHWA has sponsored research in these areas in the past, data concerning the driving experience of persons with these conditions are either incomplete or non-existent. In order to gather the needed data, FHWA has begun a series of waiver programs to allow interstate driving by persons who are fully qualified except for the medical condition which is the subject of study. It is hoped that these programs will also provide the groundwork needed to make individual determination on a driver's medical qualification and will allow drivers who are currently driving (either intrastate or interstate with good driving records but not meeting the medical fitness requirements) to continue employment as drivers, at least until the studies are completed and decisions are made concerning the pertinent medical standards.

The waiver program for persons who do not meet the vision standard is now underway and will run for three years unless terminated early by rulemaking. It is anticipated that a waiver program for insulin dependent diabetics will be instituted next, followed by programs for drivers with hearing impairments and those with epilepsy.

Linking Driver Licensing and Medical Review

The Prototype Medical Review Program project was initiated to address the administrative procedures necessary to effectively screen commercial drivers for medical fitness to drive. It was not intended to assess the medical standards per se. It is virtually impossible, however, to totally separate these two objectives. On one hand, the scope and level of medical standards to be enforced will impact how a medical review program is structured, particularly if the driver pool is large. On the other hand, a functioning medical review program should be the mechanism through which information is collected on the extent of medical problems in the driver population, and more importantly through data linkage, the effect of these medical problems on crashes, injuries and fatalities. In order to collect useful information, a medical review process that includes defensible medical standards must be in place. Furthermore, state and federal fitness requirements must be harmonized to avoid contradictions and compliance exemptions.

In addition to developing the pilot programs, several issues of principle were discussed by the Committee of States:

1. The medical certification process should be part of the licensing process.

2. Federal-state standards must be harmonized.

3. Current exemptions to federal fitness requirements sometimes contradict state standards, and need to be addressed .

4. Examining physician accountability must be reviewed.

5. The lack of data about commercial drivers hampers an effective medical certification program. The extent to which this project can establish data bases needs to be examined .

5.3 FITNESS FOR DUTY IN THE WORKPLACE: TWO METHODS FOR DETECTING IMPAIRED OPERATORS

Dr. R. Wade Allen, Systems Technology, Inc., Hawthorne, CA
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This presentation reviewed the general fitness-for-duty (FFD) problem, discussed test evolution and established pass criteria and presented an overview of two tests: a psychomotor task and a simulated driving task.

Background

There are three general categories of testing for FFD:

* Body fluid tests such as the breathalizer, and urine and blood sampling. These tests are not always practical, and when laboratory analysis is required the results are not available soon enough to avoid unsafe job performance;

* Behavioral tests such as psychomotor and cognitive tasks that can be implemented on personal computers and give screening results relatively quickly;

* Simulation testing with some face validity relative to job performance (e.g. driving).

FFD test evolution starts with behavioral task development, and preliminary experiments to establish the impairment sensitivity of the task performance metrics. The next stage involves a statistical analysis of the task measurement characteristics, and the development of pass criteria and a decision strategy for making pass/fail decisions. The next stage in FFD test evolution involves validation testing with controlled impairments to determine the discriminability of the test measure and decision strategy. The final stage of FFD test evolution is field trials to demonstrate that the test can be practically administered in the work place.

In evaluating FFD tests, consideration should be given to several general aspects of test performance. First, their sensitivity to a range of impairments (alcohol, drugs, fatigue, etc.), and the behavioral characteristics that are being tested (i.e. vision, motor, psychomotor, cognitive, attention). Second, the accuracy/reliability trade off in making pass/fail decisions and the basic discriminability of the test (i.e. Type 1 and Type 2 errors). Third the testing efficiency in terms of test time versus accuracy/reliability. Finally, the testing convenience and effectiveness in the work place, including hardware and facility requirements versus job safety/productivity benefits.

Practical, real world FFD tests should have the following attributes:

* sensitivity to job performance impairment, i.e. should test require performance skills;

* a detection/decision strategy that minimizes rejection of acceptable performance and maximizes rejection of unacceptable performance;

* minimum screening time

* convenient administration procedures

* minimal orientation, training and supervision time, i.e. relatively autonomous;

* compact, low cost equipment configuration;

* minimal facility requirements

Psychomotor FFD Task

An unstable tracking task was originally set up as a vehicle mounted FFD test under NHTSA sponsorship. The driver was required to stabilize a needle on a screen with the help of the steering wheel. If the needle diverges off to the edge of the display before a minimum score was obtained, then the task is failed. Convicted drunk drivers were required to drive these cars for 6 months, while on probation, and agree to meticulously take these tests prior to driving every time. A computer recorded all tests as well as driving times. The court appointed the test administrators as probation officers and assigned the probationary drivers to them. To prevent drivers from bypassing the tests some safeguards were built in. In case the drivers failed to take the tests and continued driving, over 10 miles per hour, the horn would start blowing, and the lights would start blinking. The testing was discontinued due to some pressure from outsiders.

This task is now being applied using an IBM-PC system in real world work situations. With use of this psychomotor FFD test, a petroleum trucking company reported reduction in on the job errors of 69%. A national food product company has reported a reduction of 63% in OSHA incidents. Because of the reduced incident rates the companies were satisfied with the FFD test performance regardless of whether or not they felt they had detected impaired employees.

A Driving Simulation FFD test

This task included steering and speed control, and also required response to discrete peripheral stimuli (i.e. divided attention). The driver receives visual and auditory cuing, and the highway environment represents a straight, two lane, rural road. Performance is measured over a several minute period, and a multi-dimensional pass/fail criteria is applied to test performance. Several experiments have been performed as part of the test development process, and validation results have indicated up to 50 % failure rates due to fatigue. Further test development and validation will be required before this test is commercially applied. Results so far are encouraging, however, and the face validity of the simulation is appropriate for professional driver occupations.

In conclusion the first task was somewhat of an abstract behavioral test, whereas the second task was supposed to represent some face validity relative to driving. These tasks have generally been accepted by management and workers, and seem to give an added halo or placebo effect whereby employees report to work in good condition ready to pass the FFD test.

5.4 FITNESS FOR DUTY ON THE HIGHWAY: DETECTING FATIGUED DRIVERS

Dr. Anthony C. Stein, Systems Technology, Inc. Hawthorne, CA

Systems Technology was approached by the State of Arizona a couple of years ago to develop some Fitness for duty tests for the purpose of identifying truck driver fatigue and as a performance testing measure. The test had to be based on universal criteria although individual baselines would be more sensitive.

A driving simulation paradigm test of 20 minutes was developed. An extremely fatigued driver would be put to sleep whereas others would show differences in their results depending on their level of tiredness. It was implemented in three phases.

Phase 1

Phase 1 tasks were carried out at the Yellow freight truck terminal. There were two groups of drivers. One group took the test prior to going on duty although there was a driver who had not slept for 28 hours prior to working but was still legally capable of driving since he was not on duty during that time. There was another group who took the test after driving the regulated period of 8 hours (since the company was an established trucking company, hours were very much regulated). In this group were many who led a pretty normal working day, meeting the required sleep, and rest criteria. The results of the tests showed that the latter group fared far worse than the former. Two pretty similar groups seemed to show a diversity in their results which could be fatigue related.

Phase 2

To test a broad spectrum of drivers more than two law enforcement officers with 15 years of experience stopped every nth truck at two different points of entry into Arizona and carried out a complete evaluation asking them a variety of questions, going through their papers, evaluating their logs and so on as well as administering the fitness-for-duty (FFD) tests. Quite a few of the drivers admitted to drug abuse (cocaine, marijuana, etc.) and the results of the test corroborated with almost 50% of the drivers who were found to be unfit for duty otherwise. Statistics had claimed that almost 40% of heavy vehicle accidents occurred within 50 miles of the final destination.

Phase 3

The third phase of testing was carried out at Swift Trucking. The driving simulator had some inbuilt performance testing measures incorporated. The testing period was reduced to 8 minutes. Twenty drivers drove on the simulators for three ten-hour days from 7:00 am to 5:00 pm and one twenty hour day from 7:00 am to 5:00 am and took these tests a week at a time. Six of them were wired up for physiological testing too. Food and sleep timings were controlled strictly by the experimenters. There was a rest break every 45 minutes. Around the 13th and 14th hours the drivers started showing signs of fatigued performance. The simulation testing could not be validated with field studies due to U.S. laws.

In general, performance testing carried out by motor carrier officers could either result in a ticket being issued or a temporary withdrawal from service of the driver. But since the officers are not police and have no intention of earning revenue by issuing tickets they would just get the drivers off the road to keep the highways safe. Some of the criteria they use to decide excessive driving hours are:

*Driver not had a bath for a number of days

*40 coffee cups in use

*Blood shot eyes

*Route verification

*Presence of duplicate logs

In the future the tests must be validated for fatigue much like breathalizer tests were validated for alcohol. Miniaturized PC-based hardware needs to be provided to fit in officers' cars.

6.0 SUMMARY AND CONCLUSION

This document presents the proceedings from the 26th Annual Workshop on Human Factors in Transportation and Sessions 1 and 40 from the annual meetings of the Transportation Research Board (TRB). The work of the Workshop attendees and the TRB Session presenters addresses the reduction of human error in transportation. Much work remains to be accomplished. It is hoped that the reporting of these activities will contribute to the reduction of human error caused transportation accidents.

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4.1 Hours of Service: Rethinking an Early 20th Century Concept for the 21st Century

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APPENDIX C
TRIS ABSTRACT DATABASE SEARCH

Accidents Caused by Human Error: Addressing
A Critical Problem, Part 1

A SEARCH FROM THE

TRIS*
DATABASE

For: 72nd Annual Meeting
Session 1

* *Transportation Research Information Services (TRIS)*
A Service of the Transportation Research Board

TRB

451862 DA
ACCIDENT LIABILITY AND HUMAN FACTORS - RESEARCHING THE RELATIONSHIP
Maycock, G (Transport and Road Research Laboratory)
Printerhall Limited
Traffic Engineering and Control VOL. 26 NO. 6 Jun 1985 pp 330-335 3 Fig. 3 Tab. 4 Ref.
REPORT NO: HS-039 139
SUBFILE: TRRL; IRRD; HRIS; HSL
AVAILABLE FROM: Printerhall Limited 29 Newman Street London England
Because human error is a major contributory factor in road accidents, there is a strong case for attempting to gain an understanding of the role of human factors in relation to safety. This paper suggests that studies of "accident liability" could significantly advance our understanding of this topic, and provide a basis for further behavioural studies. There are two main difficulties in this type of work. One is the sheer complexity of the accident situation, and the other is the statistics of rare events. These problems are discussed in the paper as a preliminary to the description of a recent study of self-reported accidents experienced by a group of "accident involved" drivers. The paper concludes with a brief discussion of the relationship between the statistical approach to accident liability and other types of behavioural research. It is suggested that behavioural studies (for safety) would be better targeted if their role was that of "explaining" the associations (or differences) in accident liability revealed by the statistical analysis. (TRRL)

476957 DA
ACCIDENT PREVENTION MEASURES
Farmer, E
National School Transportation Association
National School Bus Report VOL. 21 NO. 53 Sep 1988 p 15
SUBFILE: HRIS
AVAILABLE FROM: National School Transportation Association P.O. Box 2639 Springfield Virginia 22152
Citing how the church bus tragedy in Carrollton, Kentucky was more of a human error than equipment failure, Ernest Farmer, Director of Pupil Transportation for the Tennessee Department of Education offers some safety measures which can minimize the likelihood of future tragedies. Measures include: upgrading school bus specifications, reducing dependency on the use of highly flammable sources of fuels, specifying flame retardant materials for seat covers, installing roof mounted emergency escape hatches, insisting on air braking systems, limiting the capacity of fuel tanks, enhancing visibility through the use of both roof and stop signal arm mounted strobe lighting equipment, training so that driver personnel are fully informed of the latest developments in defensive driving techniques, training field trip drivers especially, for behavioral control practices, emergency evacuation procedures, safety equipment usage and the storage of equipment inside the interior of the bus, pre-trip planning which would include a last minute check of safety items, and departing times which would allow sufficient time to reach a given destination so that the driver would not feel pressured to speed, detour from the assigned route or make any other decision which might endanger himself or his passengers.

393406 DA
ACCOUNTING FOR HUMAN ERROR
Bridle, RJ (Department of Transport, England)
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VOL. 12 NO. 1 1984 pp 3-16 6 Fig. 1 Tab. 6 Phot. 22 Ref.
SUBFILE: TRRL; IRRD; HRIS
Managers are generally unaware of literature emanating from the behavioural sciences but human frailty causes many mistakes which have great economic consequences. The paper draws on selected reading and the author's experience to describe phenomena associated with individual behaviour which might account for mistakes. It then deals with making decisions in the face of uncertainty and discusses the relevance of the topic to accounting, in economic terms, for human error. Finally it attempts to bring the two together to see what can be made of it. (Author/TRRL) This paper was presented during the 12th Australian Road Research Board Conference, Hobart, Tasmania, 27-31 August 1984.

470439 DA
ALCOHOL, DRUGS AND TRAFFIC SAFETY. ROAD USERS AND TRAFFIC SAFETY
Smiley, A; Brookhuis, KA
Van Gorcum & Comp BV P.O. Box 43 Assen Netherlands 90-232-2316-0
1987 pp 83-104 57 Ref.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Van Gorcum & Comp BV P.O. Box 43 Assen Netherlands
Traffic safety studies have clearly shown that the cause of the majority of traffic accidents is human error. A number of factors play a significant role in the production of human errors, one of which is the influence of alcohol and drugs, the topic of this chapter. In order to ascertain the effect of alcohol and drugs on traffic safety it is necessary to examine the problem from a number of perspectives. Epidemiological studies, laboratory tests of driving related skills, simulator studies and on-road studies each provide a vital part of the evidence establishing the role of any given substance to traffic safety. The relevance of each of these type of studies, their strengths and limitations, and some of the major issues and recent results in each of these areas are discussed. (TRRL)

606367 DA
ALLOWING FOR HUMAN ERROR
Aylott, R
Reed Business Publishing Limited
Surveyor VOL. 173 NO. 5096 May 1990 p 21
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Reed Business Publishing Limited Carew House, Quadrant House, The Quadrant Sutton Surrey SM2 5AD England
In this article, the findings from a detailed study by the AA Foundation for Road Safety Research into the causes of accidents in urban areas (see IRRD 829124) are discussed. The study was undertaken by the Institute of Transport Studies at the University of Leeds and covered 1254 injury accidents which occurred during 1988

in north Leeds. In addition to analysing STATS 19 data, the study focused on the human contributory factors, which were defined at four levels. Each accident was analysed using a 'chain of factors' approach, for example, 'failure to yield at a junction' (level 1) caused by 'failure to look' (level 3) caused by alcohol impairment (level 4). The overriding conclusion found by this study is that human error on the part of pedestrians in all age groups is significantly greater than for driver riders. Impairment is also much higher for adult pedestrians (18%) than drivers/riders (8%). The author of this article questions whether the major thrust of accident investigation and prevention (AIP) measures towards drivers and riders is therefore appropriate. The study highlights the inability of most pedestrians to cope with modern traffic conditions. Road junctions should be targeted for AIP measures, and further studies are needed to assess the influence of roadside parking on accidents to pedestrians.

565988 DA

AN INEVITABLE INCIDENT

FLIGHT INTERNATIONAL VOL. 136 NO. 4214 May 1990 PP 20-21 ENGLISH

SUBFILE: NWUTL; TLIB

The Indian Airlines A320 Accident At Bangalore: Human Error, Pilot Training For New Aircraft, Emergency Services At Bangalore By Mike Gaines

477296 DA

AN OVERVIEW OF TRAFFIC SAFETY IN JORDAN

Ismail, I

Institute of Transportation Engineers

ITE Journal VOL. 58 NO. 11 Nov 1988 pp 43-46 Figs. 9 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Institute of Transportation Engineers 525 School Street, SW, Suite 410 Washington D.C. 20024

It is noted that the transportation system in Jordan is chaotic. Congestion and traffic accidents are very common, and automobile deaths have become the leading cause of death in the country. In Jordan there ae 23 deaths per 10,000 cars, as compared to 4 to 5 deaths in Britain. Also, the impact of auto accidents on Jordan's economy is mounting. Jordan's traffic accidents are attributed to 3 major causes: human error, and roadway and vehicle conditions. Each of these areas are discussed. The article recomends actions which include the following: implementation of a comprehensive transportation plan; buld safer roads with acceptable geometric design standards; introduce traffic safety education and licensing programs; enforce traffic laws; establish a comprehensive data system; and incorporate the last 3 recommendations in a safety improvement program.

484202 DA

ANNUAL REPORT ON RAIL SAFETY 1987

Allan (Ian) Limited

Modern Railways VOL. 46 NO. 485 Feb 1989 pp 73-74

SUBFILE: RRIS

AVAILABLE FROM: Skybooks International Incorporated 48 East 50th Street New York New York 10022

This report published by Her Majesty's Stationery Office gives statistics on train accidents, fatalities, injuries, circumstances such as weather conditions, obstacles, human error and fires for 1987 and makes comparisons with the 1986 statistics.

429314 DA

ASSESSING THE RESPONSIBILITY FOR DISASTERS AT SEA

NEVIN, E (NATIONAL UNION OF MARINE AVIATION AND SHIPPING; TRANSPORT OFFICERS)

MOTOR SHIP VOL. 68 NO. 806 Sep 1987 PP 58P ENGLISH

SUBFILE: NWUTL; TLIB

Recent Roro Accidents, Ship Design And Human Error Eric Nevin (National Union Of Marine Aviation And Shipping Transport Officers)

493760 DA

AUTOMATION OF METROS: AUTOMATION AND HUMAN FACTORS IN THE GENESIS OF ACCIDENTS

International Union of Public Transport

UITP Revue Nov 1989 pp 353-363 Phots.

REPORT NO: Vol 38-4/1989

SUBFILE: UMTRIS

AVAILABLE FROM: International Union of Public Transport Avenue de l'Uruguay 19 B-1050 Brussels Belgium

Neuro-computers, computers which are taught to do certain tasks based on learning from examples provided, are used to provide a clue to the functioning and/or operation of the human brain. Data collected as a result shows that human error is caused by the very fact that no single incident which is known or experienced by a human is left isolated and kept under a set method of response, but is instead, subject to continuous alteration by incoming data which influences and thus changes the way the human will respond to a given situation in each new occurrence of it. Automation, on the other hand, can be programmed to react to certain situations in a split second in a set manner with no deviation from one incident to the next incident of the exact same nature. Thus, the case for automation in transit is becoming more and more predominate. French title is: Automatisation des metros: Automatismes et facteurs humains dans la genese des accidents and the german title is: U-Bahn Automatisierung: Automatisierung und menschliche Faktoren bei der Erforschung von Unfallursachen.

582251 DA

BEHIND HUMAN ERROR ACCIDENTS

LAUBER, JK (NATIONAL TRANSPORTATION SAFETY BOARD)

THE CENTER

HAZMAT TRANSPORT '91 : A NATIONAL CONFERENCE ON 1991 PP 1-33-44 ENGLISH

SUBFILE: NWUTL; TLIB

Operator Errors Lack Of Training And Experience Management Actions Encouraging Unsafe Performance Human Factors Outside The Vehicle Center, N Full Page Citation: PP 1-33-1-44

480655 DA

CATASTROPHE MODELING OF THE ACCIDENT PROCESS: EVALUATION OF AN ACCIDENT REDUCTION PROGRAM USING THE OCCUPATIONAL HAZARDS SURVEY

Guastello, SJ
Pergamon Press Limited
Accident Analysis and Prevention VOL. 21 NO. 1 Feb 1989 pp 61-77
2 Fig. 4 Tab. Refs.
SUBFILE: HRIS
AVAILABLE FROM: Engineering Information, Inc Document Delivery Service, Room 204, 345 East 47th Street New York New York 10017

The report details a catastrophe theory model of the accident process with empirical validation. According to the cusp model, two distinct levels of risk can be observed for a distribution of group accident rates, one at 0.0 Occupational Safety and Health Association (OSHA)-reportable accidents per 100 person-years of exposure and one at 11.5. Changes within or between the two levels are determined by two control parameters: environmental hazard (asymmetry) and operator load (bifurcation). The sample consisted of 68 work groups from 8 Milwaukee-Chicago area sheet metal mills and foundries who completed the Occupational Hazards Survey (OHS). The OHS contributed six bifurcation variables (safety management, life stress, physical stress anxiety, beliefs about accident control, and experience) and two asymmetry variables (environmental hazards and danger). All organizations received an interpretive report of their survey responses with recommendations for accident control, and had held their reports for two to nine months at the time the follow-up accident rate data were collected. There were two additional bifurcation variables: months holding report and group size. Regression analysis determined that the cusp model (R square = .42) was more than twice as accurate as the best log-linear or linear alternative. Accidents were successfully controlled by safety managers' attention to recommendations produced by the OHS analysis. Catastrophe theory provided some novel insights regarding the linkage between predictor variables and actual behavior. Research has shown that a substantial percentage of occupational accidents are the result of human error. In an effort to explain and predict such errors in a systematic manner, an accident process model based on the cusp catastrophe is developed and tested. The model offers several unique and useful properties. Environmental and human performance factors can be operationalized as sets of more specific variables. In this application, The Occupational Hazards Survey was used to gather data from mill and foundry workers pertaining to hazards and dangers, adequacy of safety management, stress, anxiety, and beliefs about accident control. Workgroup size was included as an additional predictor variable in the human performance category. The experiment evaluated change in accident rates as a function of initial accident rates, survey variables, group size, and implementations of recommendations derived from the survey data. On the basis of the results, it was possible to conclude (1) qualitative variables and recommendations significantly impacted on accident rates, and that (2) the nonlinear model was a superior predictor of change compared to a linear model containing the same qualitative variables.

477875 DA

CHEMICAL STOCKPILE DISPOSAL PROGRAM. RISK ANALYSIS OF THE DISPOSAL OF CHEMICAL MUNITIONS AT REGIONAL OR NATIONAL SITES.

Barsell, AW; Bellis, EA; Bolig, CA; Deremer, RK; Everline, CJ
GA Technologies, Incorporated San Diego California
Aug 1987 1158p
REPORT NO: GA-C-18563; SAPEO-CDE-IS-87006
SUBFILE: RRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

This document has been prepared for the U.S. Army to support the Final Programmatic Environmental Impact Statement for the Chemical Stockpile Disposal Program.The report describes the results of a Comprehensive probabilistic assessment of the frequency and magnitude of chemical agent release for the storage, handling, on-site transportation, off-site transportation, and chemical demilitarization plant operations associated with the disposal of the chemical stockpile at two regional disposal sites or at a single national disposal site. Rail transportation from seven sites, air transportation from two sites and water transportation from one site were the offsite transportation modes analyzed. Both internal accident initiators (e.g., human error, equipment malfunction) and external accident initiators (e.g., earthquakes, airplane crashes) were included in the analysis. See also AD-A193354.

493974 DA

CLASSIFICATION AND REDUCTION OF PILOT ERROR

Rogers, WH; Logan, AL; Boley, GD
Boeing Commercial Airplane Company P.O. Box 3707 Seattle Washington 98124
Sep 1989 173p
REPORT NO: NAS 1.26:181867; DOT/FAA/DS-89/24
SUBFILE: ATRIS; NTIS
AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Human error is a primary or contributing factor in about two-thirds of commercial aviation accidents worldwide. With the ultimate goal of reducing pilot error accidents, this contract effort is aimed at understanding the factors underlying error events and reducing the probability of certain types of errors by modifying underlying factors such as flight deck design and procedures. A review of the literature relevant to error classification was conducted. Classification includes categorizing types of errors, the information processing mechanisms and factors underlying them, and identifying factor-mechanism-error relationships. The classification scheme developed by Jens Rasmussen was adopted because it provided a comprehensive yet basic error classification shell or structure that could easily accommodate addition of details on domain-specific factors. For these purposes, factors specific to the aviation environment were incorporated. Hypotheses concerning the relationship of a small number of underlying factors, information processing mechanisms, and error types identified in the classification scheme were formulated. ASRS data were reviewed and a simulation experiment was performed to evaluate and quantify the hypotheses.

478735 DA

COMPONENTS OF TRAFFIC SAFETY. UNITED NATIONS: WORKSHOP ON TRAFFIC SAFETY, SEP 28 - OCT 1987, LINKOEPING, SWEDEN. PART 1-2
Rumar, K
National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden
1987 8p 4 Fig.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden
Initially the size of the road accident problem in the world is described. The concept of accident is discussed and the difficulties of finding the causes of road traffic accidents are analyzed. It is pointed out that although safety is a goal in road transport, it is a secondary goal which, however, interacts with the primary goal (efficiency) and the other secondary goals (economy, environment). The history of road transport development runs parallel to and is closely related to the industrial revolution. In the process of motorization countries go through problems that show many similarities. We can learn from each other's mistakes. At present the road accident risk in developing countries is often ten to twenty times higher than in the developed countries. The main reason for the accidents is the same in all countries -human error. Human error is caused by combinations of inherited human limitations, inadequate user education and training, and badly presented traffic situations. Accident preventive countermeasures must aim at compensating for these human limitations, at improving user behaviour and performance, and at avoiding road and traffic situations in which these limitations may have serious effects. In order to manage that task we have to increase our knowledge of human performance and apply it to selection, behaviour improvement and changes in roads and vehicles. The paper tries to show and exemplify how the main components of traffic safety, that is: the road user, the road environment, the vehicle may be treated and modified in order to reach improved road safety.(a) for the covering abstract of the conference see IRRD 808557. (TRRL)

490440 DA
ERROR ANALYSIS AND APPLICATIONS IN TRANSPORTATION SYSTEMS
Lourens, PF
Pergamon Press plc
Accident Analysis and Prevention VOL. 21 NO. 5 Oct 1989 pp 419-426 1 Fig. Refs.
SUBFILE: HRIS; MRIS; RRIS; ATRIS; UMTRIS
AVAILABLE FROM: Pergamon Press, Incorporated Maxwell House, Fairview Park Elmsford New York 10523
This paper presents an overview of the field of error analysis. Section 1 shows why discussions about human error are relevant for societal safety. With regard to safety research, it is important to predict abnormal events. At the machine side, reliability studies proved their value, but to predict failures in the human factor has been shown to be very difficult. Therefore, problems in how to define the notion of human error (Section 2) and how to classify different types of error (Section 3) are discussed. Some researchers started to use systematical classifications of human error types based on a recent, hierarchical model of human task performance. The outline of the model is presented. Examples of error analysis studies from the field of transportation research (Section 4) provide some basic suggestions on how to reduce error rates. Some conclusions on error control are given in Section 5. The responsibility of managers and system designers in this respect is strongly emphasized.

470440 DA
EVALUATION OF EDUCATIONAL PROGRAMMES. ROAD USERS AND TRAFFIC SAFETY
Heinrich, HC
Van Gorcum & Comp BV P.O. Box 43 Assen Netherlands 90-232-2316-0
1987 pp 105-15 1 Ref.
SUBFILE: HRIS; TRRL; IRRD
AVAILABLE FROM: Van Gorcum & Comp BV P.O. Box 43 Assen Netherlands
Road safety education plays an increasing part in a systematic approach to road accident prevention. This is probably due to the realization that human error is an important contributory factor in accident causation. Road safety education can potentially reduce the probability of these human errors by influencing the road user by changing his perceptions, awareness, attitudes, skills and behaviour. This paper discusses the major questions which arise in conjunction with the planning, execution and application of evaluation studies of road safety education programmes. In particular the following questions are examined: (1) what are the benefits and objectives of evaluation studies? (2) what types of evaluation studies are available? (3) can the questions considered informative be answered solely through empirical research? (4) what scientific exactitude is necessary for empirical evaluation studies? (5) what are the criteria to be used in determining the scientific exactitude of such studies? (6) should summing up evaluation be carried out in each case? (7) which concealed reasons for evaluation can turn such studies into dubious undertakings? (8) what can be done when the results of summing up evaluations do not meet expectations? (9) how much leeway does one have in deciding upon a course of action if the results of a summing up evaluation are not AS Expected? And (10) can results of summative evaluations be available too late? (TRRL)

492155 DA
FATIGUE, ALCOHOL AND DRUG INVOLVEMENT IN TRANSPRTATION SYSTEM ACCIDENTS
Lauber, JK; Kayten, PJ
Brain Information Service
Alcohol, Drugs and Driving VOL. 5 NO. 3 Jun 1989 pp 173-184 Figs. Tabs. Refs.
SUBFILE: HRIS
AVAILABLE FROM: Brain Information Service Brain Research Institute, California University, Los Angeles Los Angeles California 90024-1746
In recent years, NTSB investigators have delved increasingly into the 'why' of human errors accidents. It has now become fairly routine for the human performance investigator to dig deeply into individual 'life-style' issues in order to learn what may have affected the performance of a pilot, engineer, ship's captain, or truck driver. Virtually always, an attempt is made to reconstruct the on-duty/off-duty/rest/sleep/wake history of the key operatioal personnel involved in an accident. Frequently, data are ambiguous, so the true

incidence of fatigue as a causal or contributory factor is largely unknown.

481958 DA

FROM PRONENESS TO LIABILITY --ROAD USER BEHAVIOR. THEORY AND RESEARCH. PAPERS PRESENTED AT THE 2ND INTERNATIONAL CONFERENCE ON ROAD SAFETY HELD IN GRONINGEN, NETHERLANDS, AUGUST 1987

Grayson, G; Maycock, G

VAN GORCUM & COMP BV PO BOX 43 Assen Netherlands 90-232-2369-1

1988 234-41

SUBFILE: HRIS; TRRL; IRRD

As a result of in-depth or at-the-scene accident investigations, the predominant role played by 'human error' in traffic accidents is now an established fact. It might be expected, therefore, that the study of the way in which individual road users differ in their liability to have road accidents would be one of the best documented and active areas of traffic safety research. In reality, this is far from the case. The study of the factors that influence an individual's liability to have accidents has had a long history. Indeed, the area seems to be notable more for past attainments than for current activity. For example, what is probably the most frequently quoted phrase about the subject -'a man drives as he lives' -is nearly forty years old. Further, there is a lack of consensus about the most appropriate methods of investigation, about the analysis of data, and about the interpretation of results. Worse, there is little evidence of any real progress after what amounts to decades of research. In short, the area gives the impression of being a research programme that has run out of steam. The purpose of this chapter is to look at the reasons for the past decline, to note some promising methodological developments in the last decade, and to argue for renewed interest and activity in this field.(a) for the covering abstract of the conference see IRRD 815404.

430031 DA

HUMAN ERROR AND COCKPIT DESIGN

AIRLINE EXECUTIVE VOL. 12 NO. 2 Feb 1988 PP 20-21 ENGLISH

SUBFILE: NWUTL; TLIB

BY ALLAN R. SCHOLIN SOCIETY OF AUTOMOTIVE Engineers Aviation Research And Education Foundation Conference On Pilot Error

401415 DA

HUMAN ERROR -- INEVITABLE, BUT MANAGEABLE

HAWKINS, F

LLOYD'S AVIATION ECONOMIST VOL. 2 NO. 6 Mar 1985 PP 19P ENGLISH

SUBFILE: NWUTL; TLIB

BY FRANK HAWKINS

472729 DA

HUMAN-ERROR REDUCTION AND SAFETY MANAGEMENT

Petersen, D

Aloray Incorporated 1004 Grand Boulevard Deer Park New York 11729

1984 229p Figs. Refs.

SUBFILE: UMTRIS

AVAILABLE FROM: Aloray Incorporated 1004 Grand Boulevard Deer Park New York 11729

This is a theoretical approach which focuses on the "people", aspect of the problems in safety in industrial management. It proposes that accidents are caused by people doing things unsafely despite the fact that they know better, they still make a logical choice to act in an unsafe manner and that most people placed in the same situation would make the same unsafe choice. The book attempts to promote accident prevention, error reduction and goes beyond just safety.

612412 DA

HUMAN RELIABILITY AND RISK MANAGEMENT IN THE TRANSPORTATION OF SPENT NUCLEAR FUEL. RELIABILITY ON THE MOVE: SAFETY AND RELIABILITY IN TRANSPORTATION. PROCEEDINGS OF THE SAFETY AND RELIABILITY SOCIETY SYMPOSIUM 1989, BATH, 11-12 OCTOBER 1989

Tuler, S; Kasperson, RE; Ratick, S

Elsevier Applied Science Publishers Limited Crown House, Linton Road Barking Essex IG11 8JU England 1-85166-425-4

1989 pp 169-194 18 Ref.

SUBFILE: HRIS; TRRL; IRRD

AVAILABLE FROM: Elsevier Applied Science Publishers Limited Crown House, Linton Road Barking Essex IG11 8JU England

This paper summarizes work completed on human factors contributions to risks from spent nuclear fuel transportation. Human participation may have significant effects on the levels and types of risks from transportation of spent nuclear fuel by enabling or initiating incidents and exacerbating adverse consequences. Human errors are defined to be the result of mismatches between perceived system state and actual system state. In complex transportation systems such mismatches may be distributed in time (e.g., during different states of design, implementation, operation, maintenance) and location (e.g., human error, its identification, and its recovery may be geographically and institutionally separate). Risk management programs may decrease the probability of undesirable events or attentuate the consequences of mismatches. This paper presents a methodology to identify the scope and types of human-task mismatches and to identify potential management options for their prevention, mitigation, or recovery. A review of transportation accident databases, in conjunction with human error models, is used to develop a taxonomy of human errors during design for the pre-identification of potential mismatches or after incidents have occurred to evaluate their causes. Risk management options to improve human reliability are identified by a matrix that relates the multiple stages of a spent nuclear fuel transportation system to management options (e.g., training, data analysis, reulation). The paper concludes with illustrative examples of how the methodology may be applied. (Author/TRRL)

481932 DA

IN-DEPTH ANALYSIS OF ACCIDENTS: A PILOT STUDY AND POSSIBILITIES FOR FUTURE RESEARCH –ROAD USER BEHAVIOR. THEORY AND RESEARCH. PAPERS PRESENTED AT THE 2ND INTERNATIONAL CONFERENCE ON ROAD SAFETY HELD IN GRONINGEN, NETHERLANDS, AUGUST 1987

Oude EGBERINK, H; Stoop, J; Poppe, F

VAN GORCUM & COMP BV PO BOX 43 Assen Netherlands

90-232-2369-1

1988 12-9

SUBFILE: HRIS; TRRL; IRRD

Until recently the Netherlands did not carry out in-depth research on road traffic accidents. Due to the high number and the severity of road traffic accidents, and in response to a particularly large motorway accident, it was considered appropriate to explore the possibility of using the results of such research to improve traffic safety. A research protocol was developed in which an important role is played by a multidisciplinary accident analysis team and a "called out" team. A number of conclusions can be drawn from the results of an in-depth analysis of accidents: (1) the multidisciplinary approach seems a very adequate way to do such research; and (2) at this stage of development the method seems more appropriate for studying one specific traffic safety problem that of accidents at one specific location, than for any sort of accident research. The results of the study indicate that there are a number of directions in which further research is wanted: (1) a study of the relations between accidents, conflicts, and the undisturbed traffic process; (2) a more fundamental study of the application of human error modelling theories in accident research; and (3) methods to communicate the results of this type of research to road designers, and, last but not least, the road user. For the covering abstract of the conference see IRRD 815404.

480165 DA

IN-DEPTH RESEARCH OF ROAD TRAFFIC ACCIDENTS

Oude Egberink, HJH

Delft University of Technology, Netherlands Faculteit der Maatschappijwetenschappen, Kanaalweg 2B 2208 Delft Netherlands

Jun 1987 50p 13 Ref. DUTCH

SUBFILE: HRIS; TRRL; IRRD

This report describes a pilot study into the possible use of a method of in-depth research of road traffic accidents in the Netherlands. The study was carried out by a multidisciplinary accident analysis team on the basis of one specific type of accident on one location. On the spot data collection was carried out by a special investigation team. The data were collected by means of questionnaires for the drivers involved and possible witnesses, as well as a number of checklists for vehicle, road and environmental conditions. As an extra check on the data, the research site was kept under continuous video-observation during the entire research period (1.5 years). Apart from the activities of the analysis team and the special investigation team, some first steps are presented to explain the accidents on the basis of theories from the field of human error modeling. The report concludes with a number of suggestions for further research into the field of in-depth research of road traffic accidents.(Author/TRRL)

483488 DA

IN-VEHICLE INFORMATION SYSTEMS

Rumar, K

INDERSCIENCE ENTERPRISES LTD

INTERNATIONAL JOURNAL OF VEHICLE DESIGN VOL. 9 NO. 4/5 1988 548-56

SUBFILE: HRIS; TRRL; IRRD

In-depth accident analyses point to driver problems with information acquisition and processing as the major cause of human errors, and thereby of accidents. To analyze information needs, the driver's tasks are split up into five levels: (1) strategic planning; (2) navigation; (3) traffic integration; (4) road following; and (5) vehicle handling. For each of these levels, the information problems and means to overcome them with in-vehicle electronic information systems are analyzed. The most promising areas seem to be (1), (2) and (4). Critical areas are system reliability, personal relevance, prediction capacity, user friendliness, distraction effects and price.(a)

474315 DA

INCIDENCE, REGULATION, AND MOVEMENT OF HAZARDOUS MATERIALS IN NEW JERSEY

Soeteber, PK

Transportation Research Board

Transportation Research Record N1063 1986 pp 8-14 3 Fig. 11 Tab. 1 Ref.

SUBFILE: HRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The New Jersey Department of Transportation adopted regulations governing the transportation of hazardous materials by truck and rail, as mandated by the state legislature; these regulations took effect on March 18, 1985. Concomitantly, the state initiated steps to find out as much as possible about the movement of hazardous materials in New Jersey, in addition to the frequency and severity of hazardous material incidents in the state. Described are the incidence and means of hazardous materials transportation in New Jersey. Tonnage estimates of hazardous materials transported by rail, truck, air, and water were developed from 1982 TRANSEARCH data. Intrastate tonnage of hazardous materials was estimated at 31.9 million tons; interstate inbound tonnage of hazardous materials was estimated at 21.5 million; and interstate outbound hazardous material tonnage approximated 32.1 million tons. Hazardous material tonnage represented approximately 45 percent of all freight tonnage. Between 1971 and 1984 (the period during which these data were recorded), 3,417 hazardous material incidents were recorded to have taken place in New Jersey. Six deaths, 335 injuries, and $3.3 million in damages were reported during this time period. Most of the incidents (91 percent) were related to the highway mode of travel; 7 percent were related to rail transport. New Jersey also originated 10,746 shipments involved in incidents occurring elsewhere across the nation. The majority of these incidents were due to human error (44 percent) or package failure (22 percent). Only 2 percent were the result of vehicular accidents or derailments. This paper appeared in Transportation Research Record N1063, Transportation of Hazardous Materials.

378411 DA
MAN--THE WEAK LINK IN ROAD TRAFFIC
Rumar, K (National Swedish Road & Traffic Research Institute)
Inderscience Enterprises Limited
International Journal of Vehicle Design VOL. 4 NO. 2 Mar 1983 pp 195-204 7 Fig.
SUBFILE: TRRL; IRRD; HRIS
To take effective safety measures to prevent road accidents it is necessary to understand why accidents happen. The road traffic environment makes many unnatural demands on vehicle drivers. When driver performance fails to meet these demands, accidents occur. The failure of traffic system designers to take account of human limitations is often the underlying cause of accidents attributed to human error. By basing the design of the road, the road environment, vehicles, signs, signals and regulations on human performance characteristics and limitations, many human errors could be eliminated. This action would be an effective complementary measure to the more traditional selection and improvement of road users. (Author/TRRL)

457372 DA
MASS TRANSIT: INFORMATION ON SEPTA COMMUTER RAIL OPERATIONS
General Accounting Office Resources, Community, and Economic Development Division Washington D.C. 20548
Jan 1986 20p
REPORT NO: GAO-RCED-86-46
SUBFILE: UMTRIS
AVAILABLE FROM: GAO-Document Handling & Info Services Facility P.O. Box 6015 Gaithersburg Maryland 20877
During 1984 the commuter railroad operations of the Southeastern Pennsylvania Transportation Authority (SEPTA) had six train accidents involving passenger injuries. The other four rail commuter operations in the Northeast together had fewer accidents and SEPTA's 90,000 riders is the second smallest ridership among all these operators. According to SEPTA human error during adverse weather conditions was the most frequent cause of its accidents. During 1985 on its own SEPTA increased employee training, improved the condition of plant and equipment, and increased the monitoring of train operations. A SEPTA-sponsored study and another undertaken by FRA included recommendations for safety, training and other changes. UMTA provided funds for training enginemen over routes they had not previously operated and for training newly hired enginemen and conductors. GAO concludes that it appeared that SEPTA was working to improve system safety. SEPTA now has a separate management unit for commuter rail, is making capital improvements, and has increased training of enginemen and conductors. Most other recommendations of the two studies are in the process of being implemented or are under consideration by SEPTA management.

603150 DA
MOTOR VEHICLE SAFETY: INFORMATION ON ACCIDENTAL FIRES IN MANUFACTURING AIR BAG PROPELLANT
General Accounting Office 441 G Street, NW Washington D.C. 20548
Sep 1990 23p 1 Tab. 5 App.
REPORT NO: GAO/RCED-90-230
SUBFILE: HRIS
AVAILABLE FROM: General Accounting Office P.O. Box 6015 Gaithersburg Maryland 20877
This report discusses recent accidental fires at the U.S. and Canadian facilities that make gas generant (propellant) for automobile air bags and at the Canadian facility that makes sodium azide, which is a main propellant ingredient. The General Accounting Office (GAO) identified the (1) general hazards associated with manufacturing propellant; (2) causes of the fires and resulting injuries; (3) safety and health investigations conducted at the U.S. facilities; and (4) the impact of the fires on suppliers' ability to meet the automotive industry's air bag needs. Some information on the causes of the fires, results of investigations, and manufacturers' corrective actions is based on unconfirmed oral evidence. The manufacturers would not provide GAO with some documentary evidence because they considered the information to be proprietary. The three principal manufacturers (2 U.S. and 1 Canadian) of air bag propellant for the U.S. automotive industry and the principal manufacturer (Canadian) of sodium azide have had a total of 11 sodium azide-related fires since February 1988. Four employees were seriously injured in two of five fires at the Canadian propellant manufacturing facility. Regarding four U.S. fires, human error was the most probable cause of two fires, equipment failure caused one, and one resulted from hydrazoic acid or metal azide. Despite disruption of sodium azide and propellant production by the 11 fires, U.S. manufacturers have been able to keep the automotive industry supplied with the propellant needed for driver-side air bags. However, the Ford Motor Company has had to market about 75,000 1990 luxury cars without passenger-side air bags because the Canadian plant was closed after the March 1990 fire. Report to the Chairman, Committee on Energy and Commerce, House of Representatives.

604663 DA
PART FOUR: AUTOMATION AND HUMAN FACTORS IN THE GENESIS OF ACCIDENTS. UITP 48TH INTERNATIONAL CONGRESS, BUDAPEST, 1989 (AUTOMATION OF METROS)
Gabillard, R
International Union of Public Transport Avenue de l'Uruguay 19 B-1050 Brussels Belgium 0378-1976
1989 pp 25-31
SUBFILE: HRIS; TRRL; IRRD
The author gives an account of the accident which occurred in 1985 at Flaujac in France when a railcar collided head on with the Paris-Rodez express. The cause was human error and in examining the sequence of events 3 basic factors leading to the accident are identified: the need to respect a timetable was found to come into conflict with the need to maintain safety; the complex nature of the timetable could have been simplified; and rules concerning conditional announcements caused confusion. The basis of these factors are found to be applicable to most accidents. A causal chain of events leading to an accident is illustrated and the most frequent areas affected by human error noted. The trend towards automation in these areas is described and the improvement in efficiency noted. The need for maintenance personnel and the operation of e.g. track heating and speed control from a central control, however, mean that even in a fully automated system there is still the possibility of human error.

The nature of human error is examined and it is suggested that man is incapable of respecting rules totally and continually. The mechanism of a neurocomputer is discussed and used to help explain human error. It is concluded that staff should be trained to be aware of their own shortcomings and that complex operations are best left to a Von Neumann machine. For the covering abstract of the conference see IRRD 827940.

376429 DA

PROCEEDINGS FIRST NORDIC CONGRESS ON TRAFFIC MEDICINE. THE MAN, THE CAUSE AND THE VICTIM

Dahlgren, B-E; Loevsund, P; Attebo, E

National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden

1982 189p Figs. Tabs. Refs.

REPORT NO: HS-034 227

SUBFILE: HRIS; HSL

AVAILABLE FROM: National Swedish Road & Traffic Research Institute Fack S-581 01 Linkoeping Sweden

These proceedings of the First Nordic Congress on Traffic Medicine contain the inaugural address, the resolutions adopted by the Congress, the awards presented, and the papers given. There were six sessions as follows: (1) The road user--limitations in information acquisition and processing; (2) Road, vehicle, environment as causes to human errors; (3) Organization of emergency health services; (4) The multitraumatized patient; (5) Safety devices; and (6) Rehabilitation of the road accident victim. An author index is provided. Linkoeping, Sweden, June 8-11, 1982.

470480 DA

PROGRAMMED STUDY ON HUMAN FAILURES

Wagenaar, WA; Van De Berg-Groenewegen, AJM; Hale, AR

Rijkduniversiteit Leiden Middelstegracht 4 Leiden Netherlands

1986 35p 67 Ref. Dutch

REPORT NO: R-86-5

SUBFILE: HRIS; TRRL; IRRD

AVAILABLE FROM: Rijkdunversiteit Leiden Middelstegracht 4 Leiden Netherlands

The main purpose of the study is to explain the role of human failure in causing accidents and the measures which can be taken to decrease this role. The reason of the subject of the study is that human failure was shown to be the most important factor of technological risk. A large number of studies on technological risk in many different areas of application has shown that accidents occur mainly because people do something wrong. These human errors can be classified according to the function which has failed, like vision, memory or risk estimation. Roughly 70% of human errors can be classified in the category of cognitive failure. Clear examples of cognitive failures are wrong diagnoses, underestimation of risk and consciously perpetrating offences. These and other themes of this kind are examined. Thereby the importance of further research is presented. (TRRL)

387194 DA

RECOMMENDATIONS FOR DRUGS IN RELATION TO PARTICIPATION IN TRAFFIC

Gezondheidsraad Commissie van de Gezondheidsraad, P.O. Box 95379 The Hague Netherlands

Jan 1983 Monograph 80p 15 Ref. Dutch

SUBFILE: TRRL; IRRD; HRIS

The majority of road traffic accidents are due to human error, and it is an established fact that alcohol consumption is an important factor. Drugs are also strongly suspected of being a contributory cause. This had led to regulations prohibiting the driving of vehicles when under the influence of alcohol and drugs (Section 26 of the Road Traffic Act). Another way of reducing the chance of people driving under the influence of alcohol or drugs is the use of publicity. From the research conducted so far, it is possible to conclude that the use of drugs already recorded as dangerous is a hazard to road safety as they impair the individual's driving ability. However, it has not yet reached the stage where it is possible to establish a direct link between the dose taken and the effect on road safety. Recommendations for further research, alternative penalties, more publicity of the risk of drug use to road safety, are presented. (TRRL)

390262 DA

ROAD SAFETY IN DEVELOPING COUNTRIES

Bridle, RJ (Transport and Road Research Laboratory)

Permanent International Association of Road Congr 2 Boulevard de la Tour Maubourg 75007 Paris France

1983 pp 63-74 3 Fig. 2 ref.

SUBFILE: TRRL; IRRD; HRIS

Using results of studies going back to 1952, the author shows the upward trend in fatality and casualty rates per vehicle in developing countries. Road accidents cost approximately 1% of developing countries gross national product. Mention is made of the work by the Overseas Unit TRRL and the World Health organisation to assess the overall problem of road safety in the third world. As most accidents result from human error, the author emphasises the need for constructing a safe road environment, for enforcing laws, and for using social and economic means to obtain better behaviour. Recommendations put forward at the World Health Organisation conference on Road Traffic Accidents in Developing Countries in Mexico, 1981, are quoted. (TRRL)

497096 DA

SAFETY ANALYSIS OF ARES

Weinstein, WW; Babcock, PS; Leong, F

Charles Stark Draper Laboratory, Incorporated 555 Technology Square Cambridge Massachusetts 02139

Oct 1987 108p

REPORT NO: CSDL-R-2013

SUBFILE: RRIS; NTIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

The approach to accessing Advanced Railroad Electronics System (ARES) safety is to compare the actual accident rate attributable to failures in the current train control systems to the predicted accident rate under full ARES operation. The current accident rate data was extracted from Burlington Northern (BN) Railroad accident statistics. The accident rate for ARES was predicted by modeling the effects of hardware failures and human errors within ARES. For the current control systems, the average number of control system related accidents on all BN lines is about 50 per year. The predicted rate if the full ARES were employed on these lines is 0.5 accidents per year. Therefore, ARES is about two orders of magnitude safer with respect to control system related accidents. The reason for this is that the ARES employs highly reliable computerized information cross-checks and clearance enforcement mecha nisms that do not exist in the current system.

457637 DA

SHOULD DOT'S TRAINING REGULATIONS AFFECTING WORKERS HANDLING, AND DRIVERS TRANSPORTING, HAZARDOUS MATERIALS BE STRENGTHENED?

Rothberg, PF

Library of Congress Congressional Research Service, Science Policy Reseach Div. Washington D.C. 20540

Apr 1986 34p 2 Tab.

SUBFILE: HRIS

AVAILABLE FROM: Library of Congress Congressional Research Service Washington D.C. 20540

Despite the importance of training as a means of reducing the frequency of human error, the DOT has issued training regulations pertaining to workers handling and drivers transporting hazardous materials in the highway mode that, in general, are vague, lack consistency, and provide little guidance or direction to industry as to the objectives, content, and desired length of the required training. Because DOT's training regulations are designed to provide a minimum "floor" level of safety, Congress might wish to examine the adequacy of DOT's current regulations and review DOT's preliminary efforts to improve its regulations in this area. This report presents background information to assess the need for regulatory change and possible options which address the various concerns raised herein. These options include requiring the Secretary of DOT to issue various types of comprehensive training regulations, encouraging States to issue special licenses for drivers transporting hazardous materials, and increasing the availability of emergency response and chemical hazards information. Alternatively, it could be argued that the private sector is already undertaking many efforts designed to promote safe operations, and that new detailed, difficult to formulate, and costly Federal regulations are unnecessary, especially in view of the safety record of this industry. Prepared for the Subcommittee on Government Activities and Transportation of the House Committee on Government Operations; the Subcommittee on Telecommunications, Consumer Protection, and Finance of the House Committee on Energy and Commerce; and the Subcommittee on Commerce, Transportation, and Tourism of the House Committee on Energy and Commerce.

380441 DA

SKID PAN TRAINING SAVES LIVES AND COSTS

Brown, PJ (South Yorkshire County Council)

IPC Building and Contract Journals Limited

Surveyor VOL. 161 NO. 4747 Jun 1983 pp 14-16 3 Fig. 1 Tab. 1 Phot.

SUBFILE: TRRL; IRRD; HRIS

Analysis shows that in about 95 per cent of accidents human error is a contributory cause and the sole cause of two-thirds of the accidents. The author describes south Yorkshire County Council's driver training centre and the techniques of skid pan design. An investigation of the published data on theoretical and practical experience showed that, although slippery surfaces and lubricants exist, they are generally unreliable or expensive. It is important to provide the largest pan that can be afforded, constructed in concrete or sand asphalt, and use recirculated water as the lubricant. The surface needs to be as level as possible but not too thin, which could lead to the formation of surface depressions, causing variation in film thickness. Some form of edge restraint is necessary - a 1 M to 2 M wide roughened concrete strip is all that is needed - gravel or banking can cause overturning. Water supply points need to be regularly spaced and the prevailing wind needs to be taken into account when deciding on the location. (TRRL)

481934 DA

THE APPLICATION OF HUMAN ERROR MODELS IN ACCIDENT HYPOTHESIS FORMULATION --ROAD USER BEHAVIOR. THEORY AND RESEARCH. PAPERS PRESENTED AT THE 2ND INTERNATIONAL CONFERENCE ON ROAD SAFETY HELD IN GRONINGEN, NETHERLANDS, AUGUST 1987

Quist, B

VAN GORCUM & COMP BV PO BOX 43 Assen Netherlands 90-232-2369-1

1988 26-31

SUBFILE: HRIS; TRRL; IRRD

In 1978, 1983 and 1986 three severe railway accidents occurred in the Netherlands on the same spot and under almost the same circumstances. The accidents took place on a section of the railway line in the province of noord brabant near the city of Eindhoven. This railway line was not equipped with automatic train control at the time. The study of all three accidents showed that the drivers were completely surprised by a left hand turn. The idea that their train should be diverted to the siding track did not even cross their mind. The conclusion from all three accidents was that the accident would not have occurred if the drivers had been informed beforehand about the manoeuvre they had to make with their train. It was recommended that accident investigation should aim not only to discover what happened, but should also discover why the accident happened, as this gave a better basis for accident prediction, and therefore for the prevention of any recurrence. For the covering abstract of the conference see IRRD 815404.

368543 DA

THE HUMAN FACTOR IN ROAD SAFETY

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Australian Road Research Board 500 Burwood Road Vermont South Victoria 3133 Australia 0572-1431

1982 pp 65-80 14 Fig. 3 Tab. 41 Ref.

SUBFILE: TRRL; IRRD; HRIS

Several studies based on accident analyses in depth have tried to establish the relative weight of vehicle, road and human factors as causes in road accidents. The results clearly point to the human factor as the main cause. But an analysis of the road traffic process and its development in a historical perspective indicates that the question and consequently also the answer are improper. It is normally not the failure of a component but the failure of a system interaction that causes accidents. However, the problem remains also with the systems approach - how to decrease the human errors in traffic. The common denominator of human mistakes seems to be lack of adequate information - from the road, the road environment, other road users and the vehicle. The information available in traffic is analysed both from the point of view of the road user and the road and traffic engineer. Possible ways to overcome informational deficiencies in the system are discussed on the basis of the three principal approaches - road user selection, road user improvement, adaptation/design of environment to road user characteristics. The conflict between the human engineering approach and the risk homeostasis hypothesis is analysed. Efforts are finally made to evaluate the possible effects of various improvements of road user selection: various ways to improve road user performance, such as education, training, enforcement; and various ways to adapt road design and delineation, road signs and signals, rules and laws, and vehicle dynamics to human characteristics and limitations (a). The number of the covering abstract of the conference is TRIS No. 368448. (TRRL) Proceedings of the Eleventh Australian Road Research Board Conference, held at the University of Melbourne, August 23-27, 1982.

441708 DA

THE PRIMACY OF THE MASTER AND ITS CONSEQUENCES

HERSHEY, R (US MERCHANT MARINE ACADEMY)

MARITIME POLICY AND MANAGEMENT VOL. 15 NO. 2 Apr 1988 PP 141-146 ENGLISH

SUBFILE: NWUTL; TLIB

Human Error And Shipping Accidents, Possible Application Of Cockpit Management Training In Air Navigation To Shipping Robert Hershey (US Merchant Marine Academy)

460279 DA

TRAINING OF WORKERS INVOLVED IN THE HIGHWAY TRANSPORT OF HAZARDOUS MATERIALS: DOT OVERSIGHT. UNION CALENDAR NO. 591

United States Congress Committee on Government Operations Washington D.C. 20510

Oct 1986 16p

REPORT NO: H.R. 99-985

SUBFILE: HRIS

AVAILABLE FROM: Government Printing Office Superintendent of Documents Washington D.C. 20402

The report is based on an investigation and hearing conducted by the Subcommittee on Government Activities and Transportation. The report recognizes that human error is responsible for most spills of hazardous materials during transportation. The Committee notes that the Department of Transportation has primary regulatory responsibility for the safe shipment of hazardous materials. However, DOT has neglected to develop strong, precise regulations regarding the training of drivers and other truck and shipping personnel. The report concludes that DOT should require trucks and shipping companies to better train their drivers and workers on the safe shipment of hazardous materials and to maintain records of such training for enforcement purposes.

611989 DA

UNDERSTANDING THE ROLE OF HUMAN ERROR IN AIRCRAFT ACCIDENTS

Berninger, DJ

Transportation Research Board

Transportation Research Record N1298 1991 pp 33-42 2 Fig. 10 Ref.

SUBFILE: ATRIS

AVAILABLE FROM: Transportation Research Board Publications Office 2101 Constitution Avenue, NW Washington D.C. 20418

The commercial aviation industry has achieved an enviable record of safety, but accidents still occur. In roughly two-thirds of aircraft accidents, aviation's human link receives the blame, and the proportion of accidents attributed to human error has not changed appreciably in 20 years. Most human error that leads to accidents surfaces in the performance of flight crews and air traffic controllers. The strategies used to address human error can be placed in two categories: introduction of technology that reduces the role of humans in the system and changes to the system and training suggested by human factors considerations. The pursuit of these approaches has largely become distinct, but they are both characterized by several basic assumptions. Both technologists and human factors specialists attribute human error to human fallibility and accept in varying degrees the inevitability of human error. Both accept the notion that humans are the most unreliable element in aviation. Both place emphasis on flight crews and air traffic controllers. Supporters of both approaches hold doubts as to the value of the other; in particular, the technologists view human factors as being too untidy to be the basis of design. The system that fails in an aircraft accident can be divided into animate (human) and inanimate components. If assumptions are reconsidered, there are mechanisms by which the inanimate system can contribute to causing the human error that leads to accidents. There is a spectrum of possible accident causes between the extremes of entirely human error or entirely inanimate system malfunction. Current interventions are heavily weighted toward the human error end of the spectrum, but this paper suggests an additional approach to interventions that alleviates system problems that cause human errors. This paper appears in Transportation Research Record No. 1298, Public Sector Aviation Issues: Graduate Research Award Papers 1989-1990.

478347 DA

VIPER MICROPROCESSOR

Kershaw, J

Royal Signals and Radar Establishment, England Malvern England

Nov 1987 28p

REPORT NO: RSRE-87014; DRIC-BR-104861

SUBFILE: ATRIS; NTIS

AVAILABLE FROM: National Technical Information Service 5285 Port Royal Road Springfield Virginia 22161

Most accidents are caused by human error. Computer control systems in aircraft, chemical plant, nuclear reactors and so on could in principle prevent many accidents, but in practice they are not reliable enough to be put in charge of human lives. This Report describes some of the developments in computer hardware and software which are needed before this situation can change, and introduces the VIPER microprocessor which has been designed specifically for ultra-reliable systems. In conjunction with a number of other RSRE Publications (see references) it defines the VIPER architecture formally and describes some of its supporting software.

481618 DA

WHAT ROLE SHOULD THE CONCEPT OF RISK PLAY IN THEORIES OF ACCIDENT INVOLVEMENT

McKenna, FP

ERGONOMICS VOL. 31 NO. 4 Apr 1988 469-84 FRANCAIS, DEUTSCH, C

SUBFILE: HRIS; TRRL; IRRD

Recently a great deal of emphasis has been placed on the role of risk in theories of accident involvement. This may be exemplified by risk homeostasis theory, which argues that the level of risk people are willing to accept is the sole determining factor in overall accident involvement. The evidence for and against this position is reviewed and it is concluded that there is little evidence in favour of the theory. Several theoretical and methodological inconsistencies are noted. It is concluded that an increased knowledge of the limitations of human risk perception will prove useful in understanding how people react to human error and accident involvement.(a) this paper was included in the proceedings of a cec workshop on risky decision-making in transport held at the tno institute for perception, the Netherlands, 9-11 November 1986. (brown,i, and janssen,w, editors).